INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURES

Digital Image Processing of
Remote Sensing Data

Lecture – 12
Spatial Filtering Techniques

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Although everyone welcome to 12th lecture of digital image processing of remote sensing data course and in this particular topic we are going to discuss a special filtering techniques and there are two types of filtering techniques which have incorporated digital image processing of remote sensing data and one based on the special filter and another one is based on the frequency and which we will discuss in the next lecture, so first we will go through this special frequency and spectral frequency so first a special frequency and that is the radical variation in this case like here.

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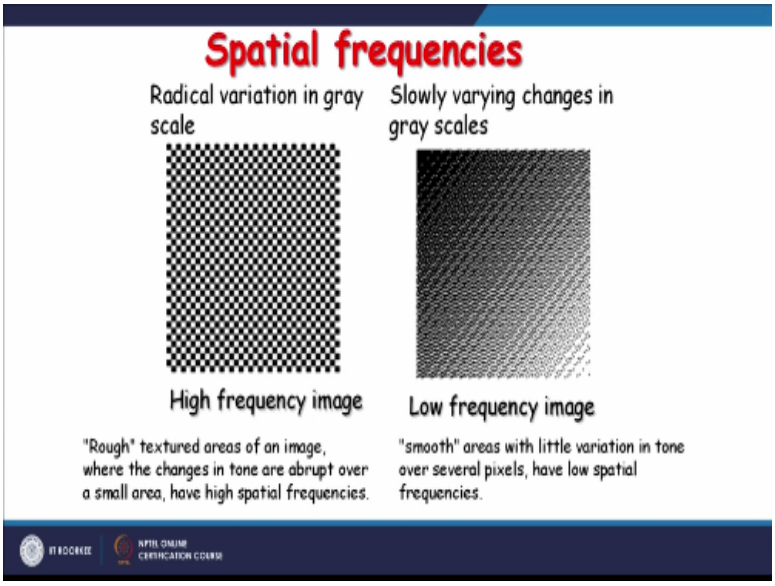

So we consider as a high frequency image and but if we go for a images sometime we get the media's which are having low frequency that means basically and high frequency and low

frequency media's that means that basically the variations in the pixel values adjacent pixel values and is high in case of high frequency which and in case of a low frequency image that the bet variation among two adjacent pixels is not that great, so the neighborhood plays very important role and those special filters are also designed accordingly.

To enhance the images so that the language quality improves for better interpretation so in this high frequency way this is rough textured areas of an image where the changes in tone are abrupt over a small area have a high spatial frequency where are we in case of low frequency it appears a very smooth area the little evaluation and tone over several pixels have no special frequency sometimes in the images we would like to highlight the features, which are more regional in character then the features.

Which are in local in character, so we will go for the futures which are revealing character we go for new frequency filtering techniques and when we want to highlight the local features then we go for high frequency filtering techniques, so that we also see and here the day if we do the image changes then we might be the results in that one.

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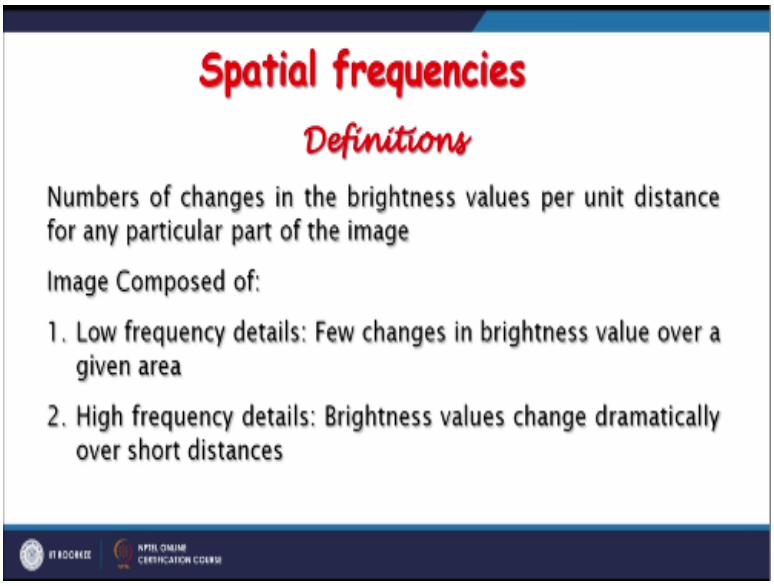

It is very special frequencies how can we define it the number of changes in the brightness values per unit distance for any particular part of the image the special filters are may be 3 by 3 pixels 5 / 5 pixels 7 / 7 pixels these numbers have to be the odd number because the center pixel is the target pixel for which the new pixel value is calculated so in this case value in case of as I have mentioned that move or concede it is reaching even brightness values over a given area that usually looks very smooth images looks very smooth.

But little features can be picked up very easily in the images which are having low frequency details and concluding to this high frequency images, the ordered a that it is the brightness value changes and dramatically abruptly over a short distance and they create high frequency details now and this special factoring techniques it is local operation.

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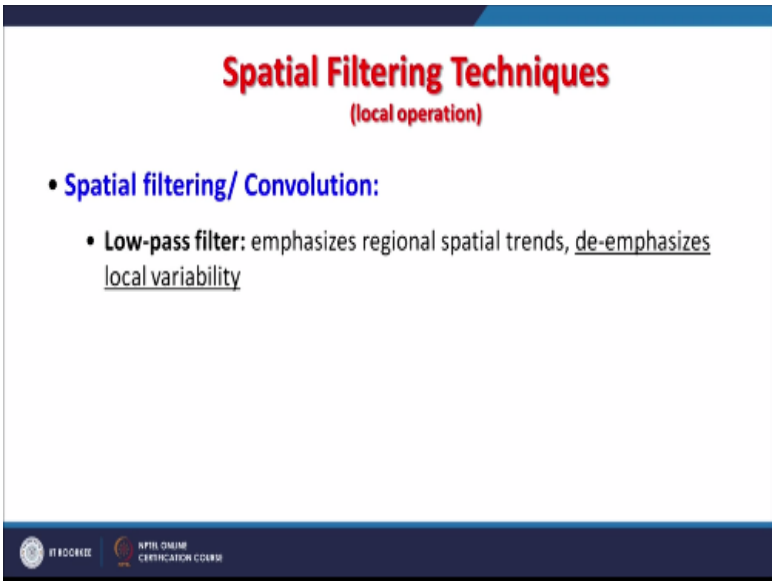

And they also call the convolution frittering technique and low-pass filter emphasizes ringing and special trends and at the same time it d emphasizes the local variation, so high frequency features are reduced and the wearers and low frequency features are enhanced or emphasized and that is the purpose of low-pass filter wherever it is of high pass filter it would grow the just opposite as good low-pass filter it will highlight the local features especially local special variability and will reduce the really special vulnerability.

And there are some other types of special filtering techniques which are also called edge enhancement techniques which combines both filters that means low-pass and high-pass and to sharpen the edges in the image, so wherever the boundaries of different features are present in the image those boundaries are sharpened and therefore may be in some cases a better interpretation cd 70 one has to remember that a single technique the brute or let me cook like this that every technique is not suitable for every kind of images.

It depends on and what is the special resolution of that image and what is the purpose our unit goal of creating a digital image processing image, so that we can get the better interpretation so there is no vessel technique or a flow of processing that this has to be applied on every images if this would have been then a simple automatic system and would have been generated even if some is working only one idea but on different in a different receivers images then everyone has to imply different language processing techniques.

To enhance that image or those images of belongs to differentiation of the same area so very straightforward in that say that every time you have to apply this it depends on the image what is the contrast what is the features and how they are presented in association, so let me carry the first example here is having 0 special frequency.

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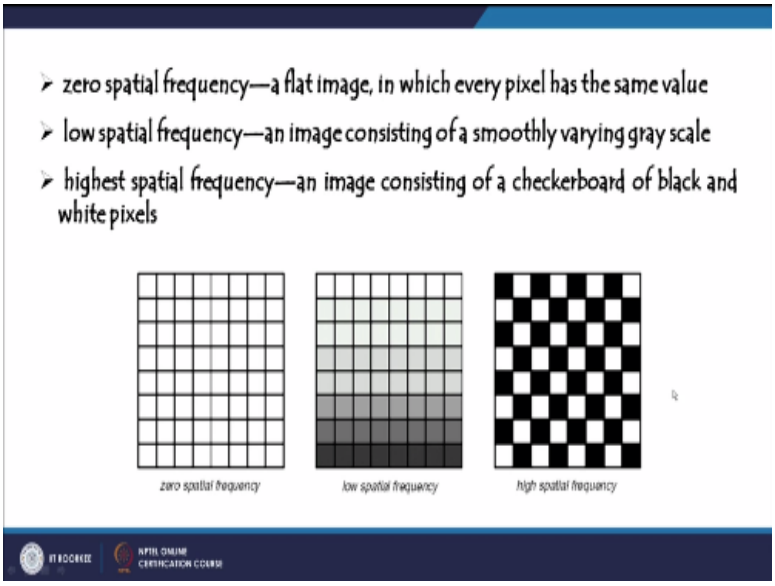

Low value some in pixels and a flat image in which every pixel has the same value it may happen where you are having a complete snow-covered areas of a flat and terrain or maybe a desert area where it was completely featureless that in and their frequency no especial frequency an image consisting of it smoothly varying grayscale, so very gently the pixel values are varying and highest spatial frequency example is already here.

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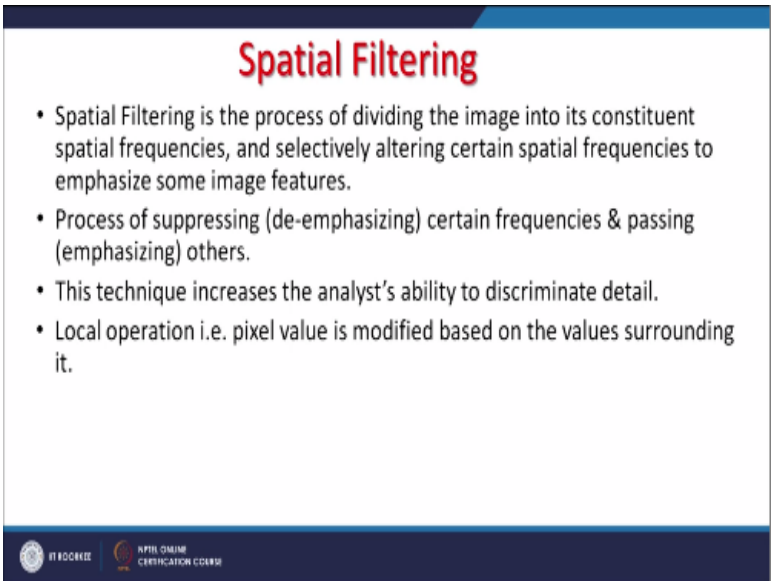

Now in filtering what they would what we do basically if we consider a three by three filter then it is moved throughout the image and for the center pixel a value is created a new value is assigned that value will come on the USB assign to the special filter that we will see here that in a specially trained the process of dividing by mailing to constituents of a special frequencies and selectively altering certain special frequencies to emphasize some image features, and this process of suppressing that is be emphasizing.

Certain frequencies and passing certain frequencies and this technique increases the analyst ability to discriminate details ultimately we are trying to improve the image quality for better interpretation or all techniques broken operation this is local operation because it has to be program and but the one on each pixel except the pixels which are present on the edges of an image so if you are having with 3/ 3 pixels 3 / 3 pixel spatial filter then one pixel on all sides will not be involved in the analysis.

But if you are having a π / 5, now filter then 2 pixels on all sides of them it will not be involved so local operations it is and the pixel value is modified based on the values surrounding it the surrounding value will decide what should be the value here and use for enhancing certain features it also can be used to remove noise like speckles sometimes we are having advising the images included lectures I have shown some images so that speckle thing then also by filtering and smoothing automation timing there are a lot of variations means high-frequency features are

event I do not want I want a smooth image appearance, so that I can group the original features so that can also be achieved the other way example.

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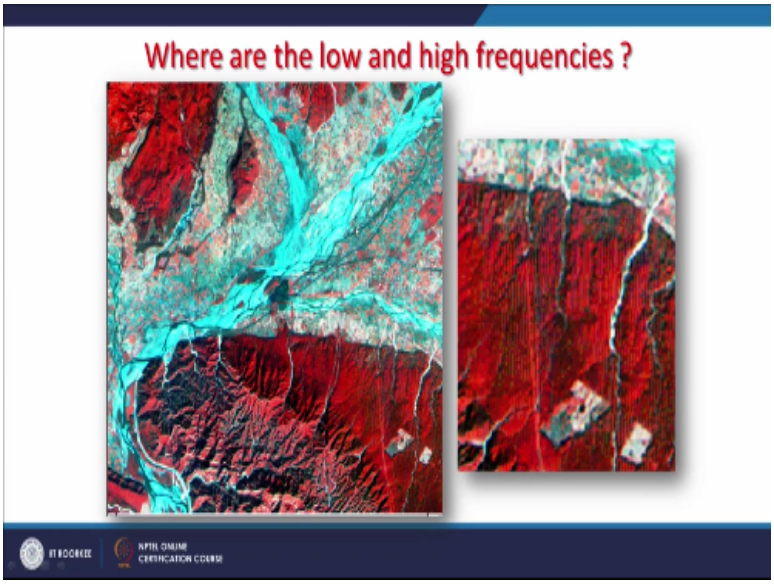

They were the new and high-frequency features are there here see this it is having very high frequency features wherever at different places you are having low frequency features this is part of our CEO Alex and near Hardwar.

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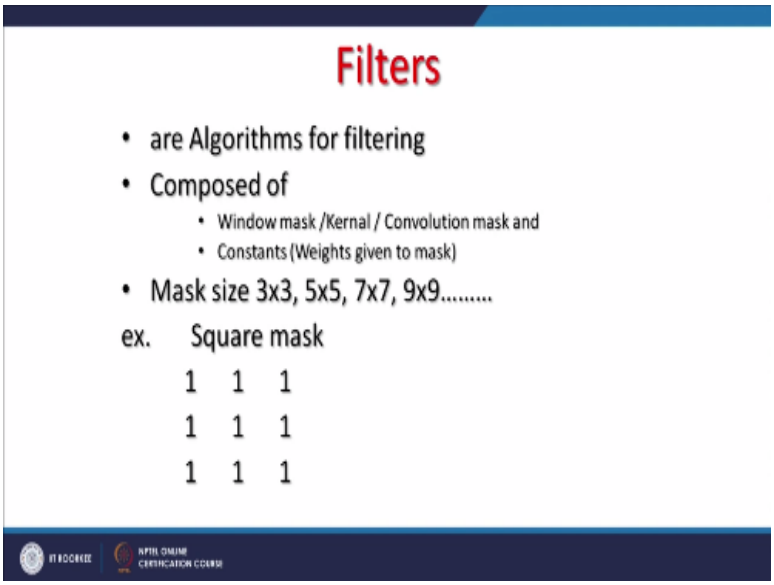

And now here and the weather and how filters are designed, so we will see one by one and that all go to algorithms for filtering that is composed of within the mask or kernel convolution mask or moving metrics of three by three like most sizes mention your 5/5 it has to be odd number in this one only when you are being, so the weight for all pixel values is same but we can have a different so this becomes a square mask it be in both 3/3 5/5.

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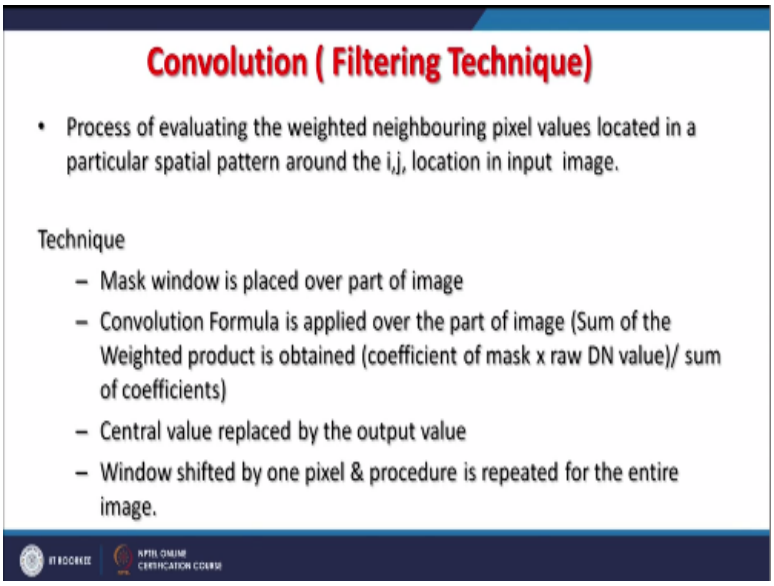

Now the conversion filtering technique the process if we define the process of relating the weighted neighboring pixel values located in a particular special pattern around the IJ location in the input image and the technique is this mask this very window the convolution filter will move over each pixel will take the values of surrounding pixels depending on the weight which has been assigned in these rural cells of this mask the new value is calculated and mass window is placed with a part of image convolution formula is applied over the part of a mean.

That is the sum of weighted product is obtained coefficient of marks X row that is the digital value divided by sum of coefficients and the center when you replace by the output value and the wind is shifted by 1 pixel and procedure is repeated for the entire image, so similarly pixel this process will be done here is the example that this is input image and in the filter now step one is to place over the part of the image.

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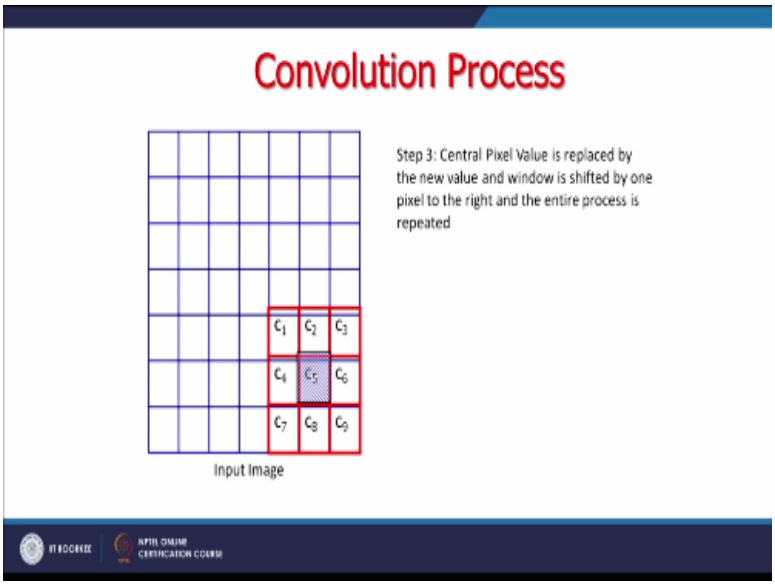

So this will go we have this image and under one it will keep moving but the same time it will calculate a new pixel value for the central pixel over which this will be placed, so here and this is now placed here and now this is how the value will be calculated so for the centre pixel that is the C5 the value is calculated and they are depending on the weight which you have been assigned this formula will be applied, so likewise and for the central pixel then step 3 it will move for the next pixel.

And likewise so now it has the C5 that means for this pixel and now a given filter has moved one step right side and the new value has been calculated then again shifting and likewise we will keep doing for entire image till it reaches to the end of image but as I have mentioned if you are moving the 3 / 3 and special filter convolution filter then one pixel on the edges will not be considered because there is and this filter cannot go on the first pixel at first row it has to be and then on second pixel second pixel of first row.

Of n first and second of first a second column and second row, so first column and first row pixel we cannot be done for the all corners and on the sides as well and the light wave it goes till the end.

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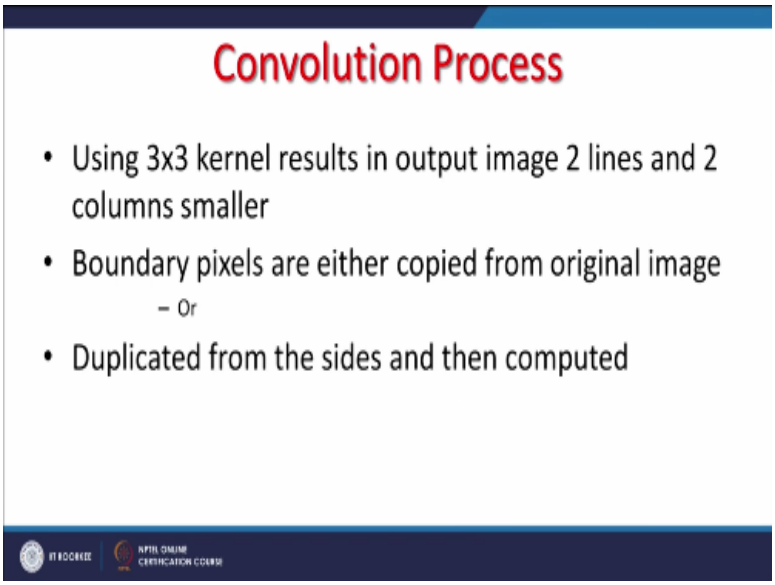

And the last pixel is and for last pixel it is calculated so moving to be very general results in output image two lines and two columns smaller the boundary pixels are either copied from original image or the period front side.

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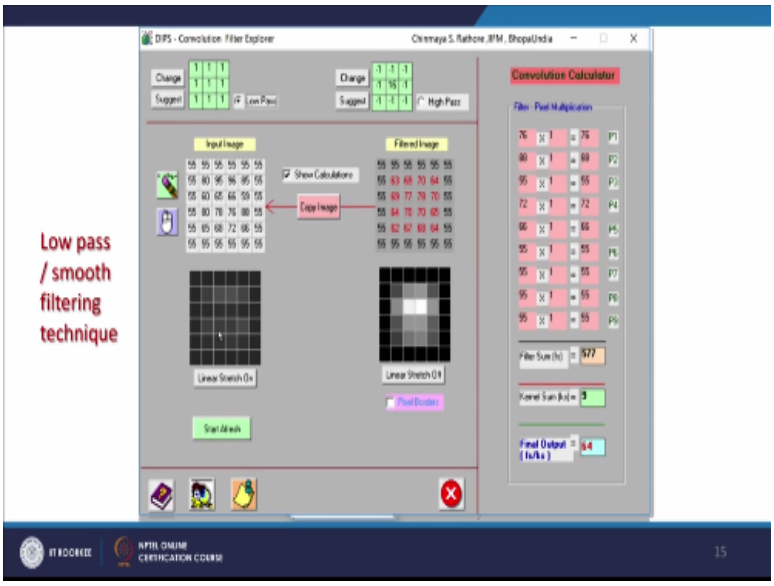

Then computed here is the example is given here and that day to the media the pixel values are given here and this is the filter low-pass filter has been applied, so it will it will use the weighted average and some of these all values weighted average and that value will be assigned to the central pixel over here so like in this case when we go for this run filter then this is what we see so the oh edges there is no change but we will see that on the other part the things will change so that.

Now this filter is here and it is calculating new value for pixel eighty and likewise this value becomes 63 and likewise the next one and then at the end you come here and the edge is one pixel y1 this is this has mode will considered but removal you have changed so the 55 55 first row is the same but the second row second pixel has changed instead of now 80 it become 63 and the 69 70 is 64, now the variations which you are present here between these pixels have reduced and therefore the high frequency features have removed and low frequency features have invested.

Have been emphasized by doing this kind of filtering and this is how the calculation is done then when it was, so 76 has been calculated considered 72 and multi because depending on the weight 76 multiplied by one and then we go for all these pixels one by then that summer-fall this is 5 7 7 it is / 9 because it is a three by three filter you get a output value 64 which is assigned and there

here, so likewise and you see the and the process and the gray values are also given here and you can for the entire unit is done.

So this last image example is so here this is 64 and this is of course linear stretched amaze you are not image that can also be seen.

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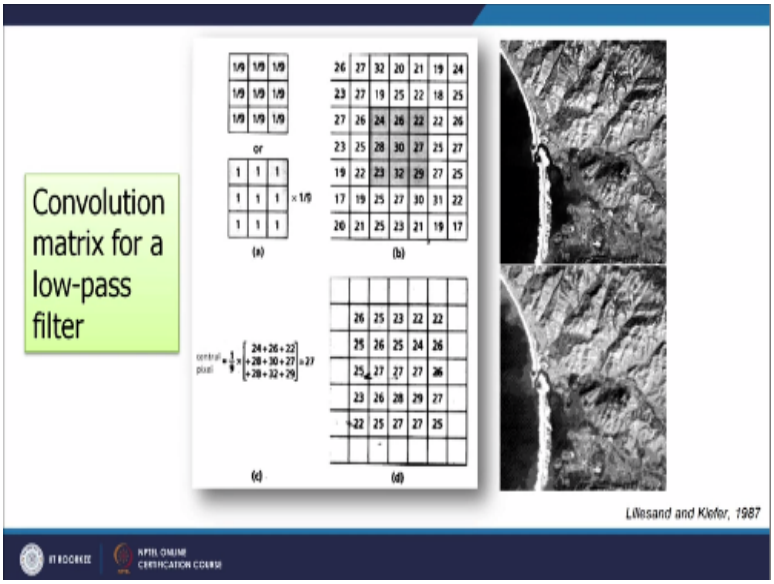

In real image this is how it, so this low-pass filter is we moved here two different examples are doing this is how the calculation the non the edges nothing is done and this is these are the results, so this is the low-pass filter and therefore the this high frequency features have been doing the size whereas low frequency features have been highlighted and this is what you are see in the result image which is a dope-ass either one by 19 20s either or 1/ 1 you can assign the weight that it build is same because.

You are multiplied by 1/1 and we end up with this image, so you can compare that what happens to the pixel value they become very close to each other and therefore the new color variations reduces do emphasize and the regional variations are emphasized.

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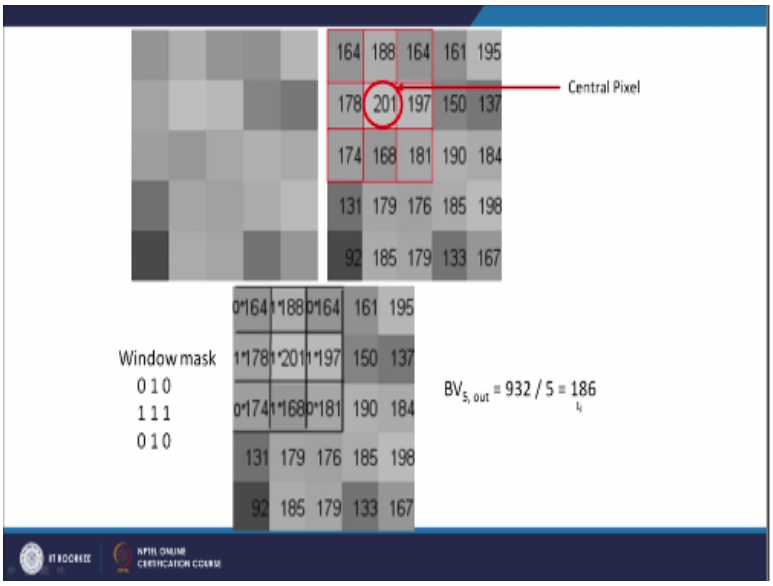

And central pixel becomes very important, so here the central pixel values in here is 20.and after the calculations it might be 186.

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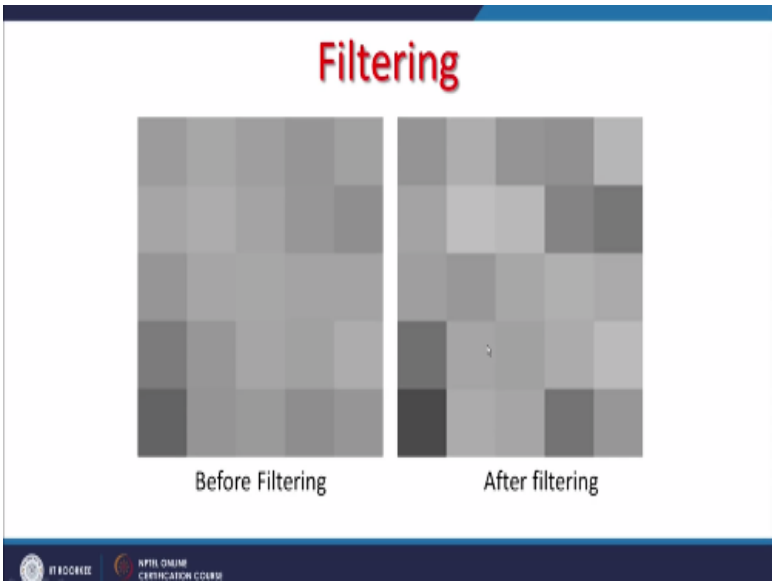

And before filtering without the situation and after filtering in case of high pass filter this is how the local variations then would be highlighted in high pass filter, so low pass filters and we block high frequency details or deal if us I have the concede it is as a smoothing effect on images used for removal of noise.

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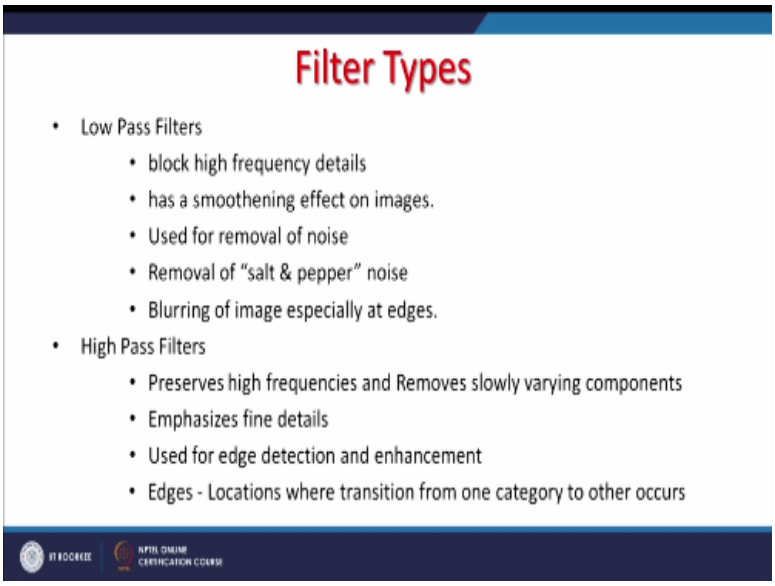

Removal of salt and pepper my salt and pepper noise that the every alternate pixel is having a very sparkle kind of thing one is dark one is light one is dark light, so that is why it is called salt-and-pepper and blurring of image especially at edges, so this definitely will one pixel problem on the edges of the image high-pass filters reverse high frequencies remove slowly varying components that means no frequency things and forth is fine details you use for edge detection and enhancement and edges locations where transition from one category to another.

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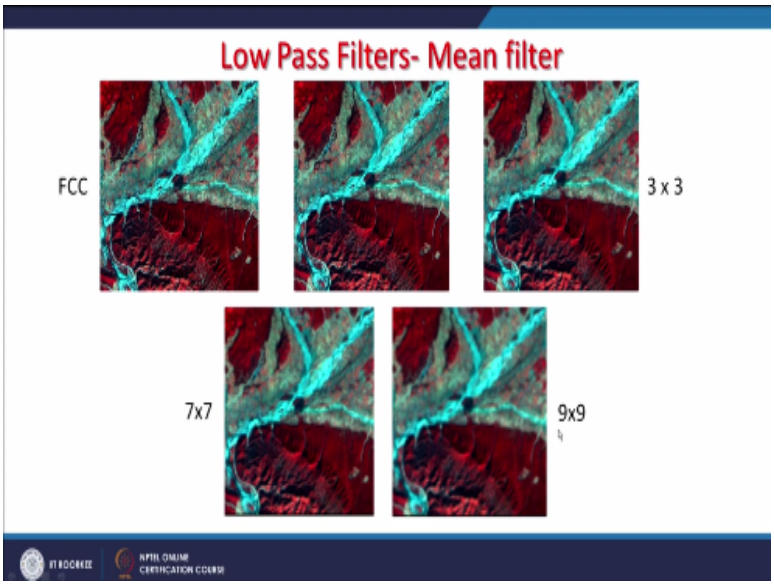

Though this is the example of shown here that if I have an original image they say if you have gone subjected to a 3/3 filter this is example of 7/7 filter and this is of 9/9 and this is how the mean the filters is the, the matrix what the filter becomes larger the good is everything the pixel values larger from the surrounding, so very other involved to calculate it pixel value for a target pixel or center pixel and therefore it will it will reduce the local variations very significantly as you can compare with mean 3/3 filtered image.

And 9/9 filter image one more thing one has to remember in order the size of the filter more the time it would take in the processing so if you are having large image usually one should go for 3/3 and see whether you are achieving the results which you wanted to have then what better way for 7/7 5/5 then maybe 7 because size if you increase the size and the processing time would increase exponentially, so this one has to remember do another example.

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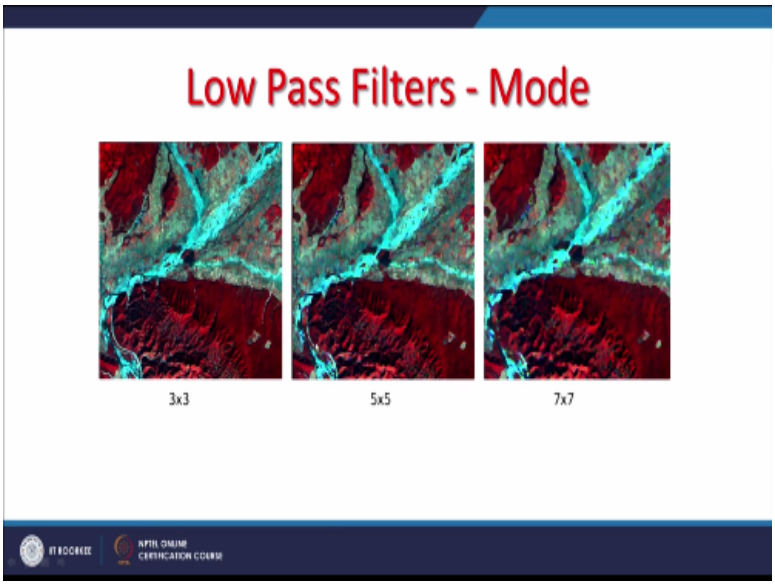

Of moving that was the new filter and new filter different definitions of low pass filter this is medium filters is there and it is doing so sizing the local variations, and emphasizing the reason it very, now this is good filter so and there is another changes are there.

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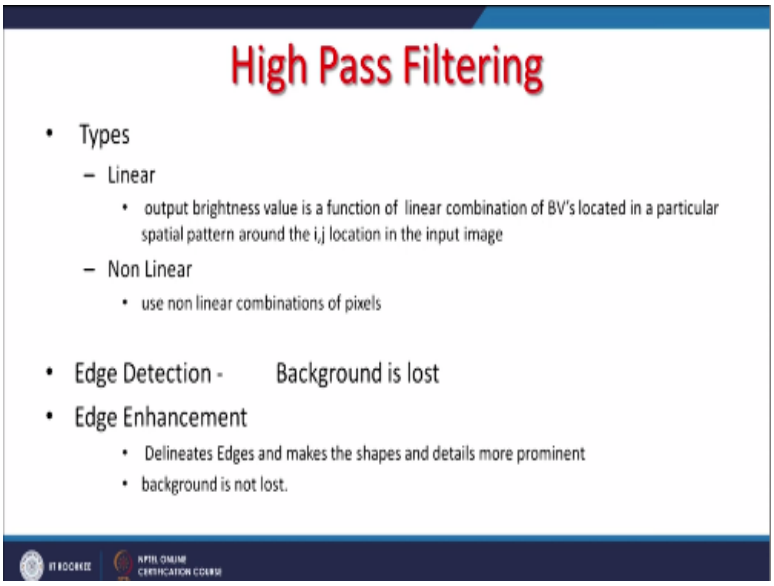

And for the same image which everything in case of high-pass filters we can take a linear or nonlinear the out brightness values in case of linear is a function of a combination of brightness values located in a particular special pattern around their pixel IJ location in the input image and, now in case of nonlinear use non linear combinations of pixels, so devalue the high-pass filter use emphasize that broken valuations will be L detection and background is lost advancements very popular and technique that gives edges and make the sharpness and it is more prominent and background is not lost.

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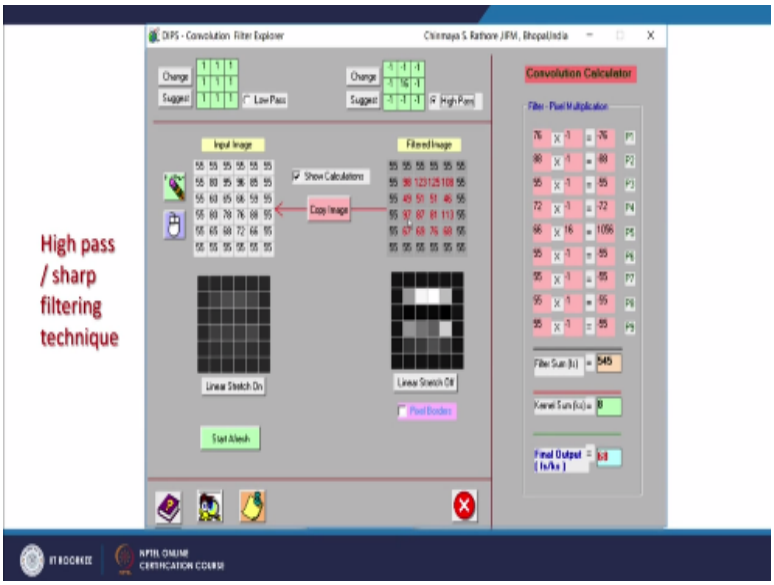

So edge enhancement edge detection enhancement this is the example here that, now we are having a high-pass filter and the center pixel will have very high weight in this 3 / 3 matrix and where surrounding pixels and it is a minus value and the resulting would see, when you go1/1 that and that see whether the first value and now we are and going to change it will become 98, so instead of 80 it becomes 98 and likewise for entire image when it is done except for the one pixel on the edges these values have changed significantly the difference between these two adjacent pixel values has changed.

Significantly earlier the difference of this 15 pixel value that near 80 and 95 now it is 98 and 123 so 25 instead of 15 difference, now we are having difference of 25 and therefore the local relations have been highlighted if say if we do with some directional touch to this filter then in that particular direction where your features are present they would be highlighted, so a high-pass filter can also and we can also modify to make a directional filter which we will see just later.

So this drill image and this is what you are seeing the enhancement in them that in a long-running sense that local variation have been highlighted very significantly just using a high-pass 3 / 3filter.

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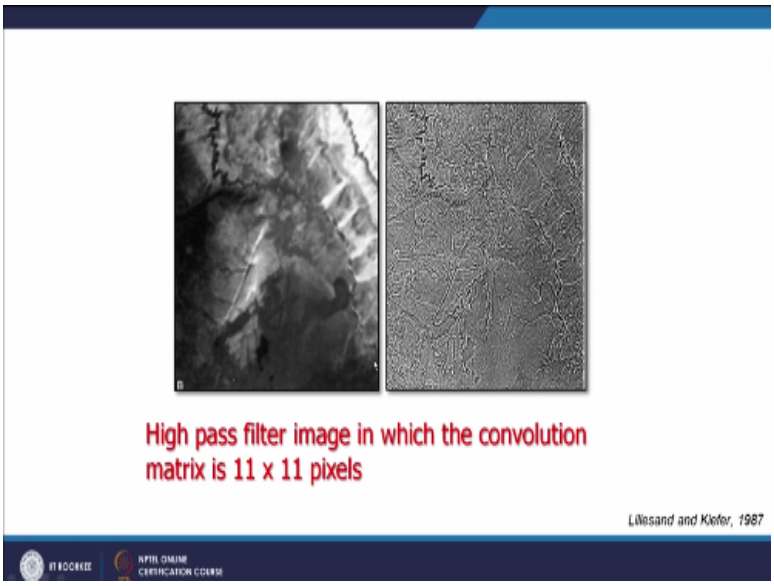

And this is high pass filter and the convolution metric that filter size is very large and therefore all the variations have disappeared almost and you are seeing just the edges of different features and all the things have been highlighted very clearly here, edge detection that is the given some cabinet and in 0, some carbonyls in which the sum of all coefficients in carmell equals 0 and this generally equals the output values to be 0 in areas where all input values are equal.

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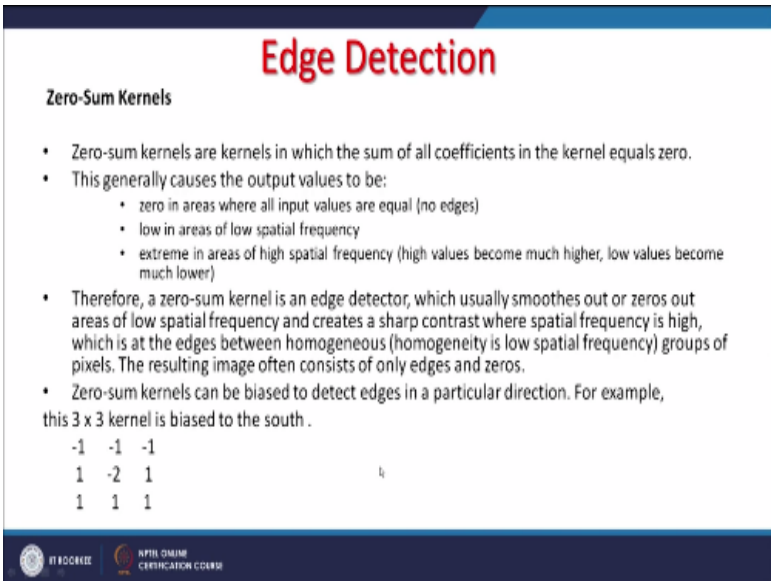

Edges very well of low frequency and extreme area of high spatial frequency therefore is 0, some kernel is an edge detector which usually smoothen out or 0 out the areas of low frequency and cases are that mean we are all these many variations will disappear when these will come and we example of this edge detection and filter maybe like this that you are having only in that top part you are having the - values whereas here you are having positive bit and the center value is having – 2 and this is a 3/3 and filter example.

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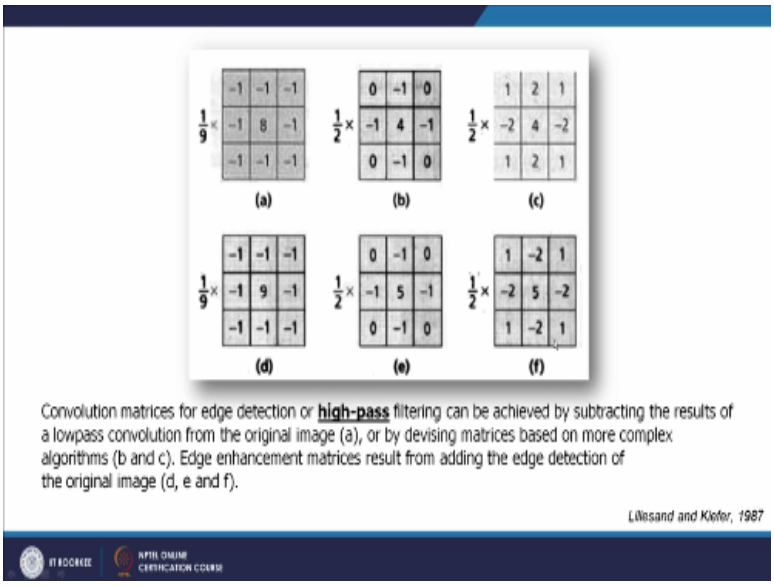

And therefore and one can design several filters as I have been mentioning this is a one and one type of special filter high-pass filter which, we have seen this is another this is another and there are few more examples are there, so here and this a is the image by dividing that is based on the more complex algorithms that is B and C there we have changed and instead of in building -1 all surrounding pixels in the filter on and all southeastward have been involved northeast Southwest become 0.

Enhancement matters as well from adding the edge detection of the original image here, now and now edge has been added so here – 2 – 4 and – 2 places including and the features which are present in East birthday we highlighted features present in different directions will be highlighted and likewise.

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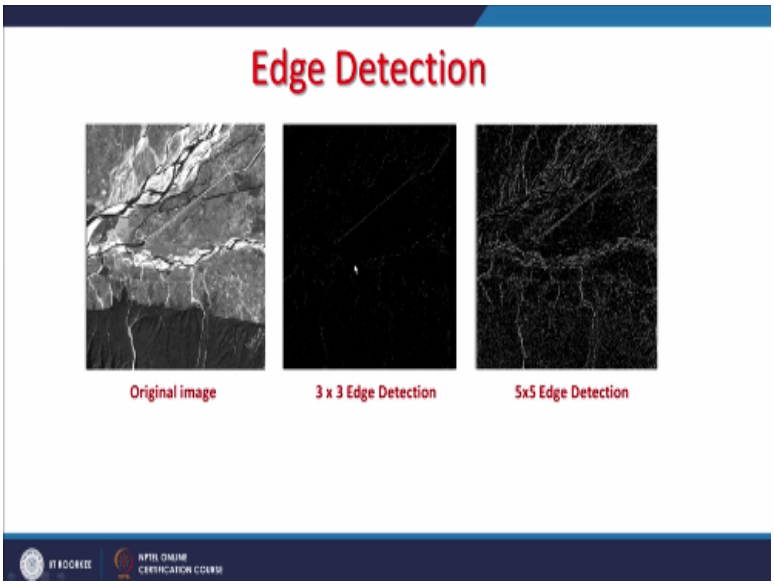

And you see that results are there and now these were examples of the original image 3 / 3edge detection, so only the features which has the sharp edges have been highlighted rest completely gone in the background, so if somebody is looking for such outputs to do certain things in your features or features and which are having sub boundaries with surroundings such shelters can be adopted and if I go for 5/ 5 edge detection highly result and we get image something like this.

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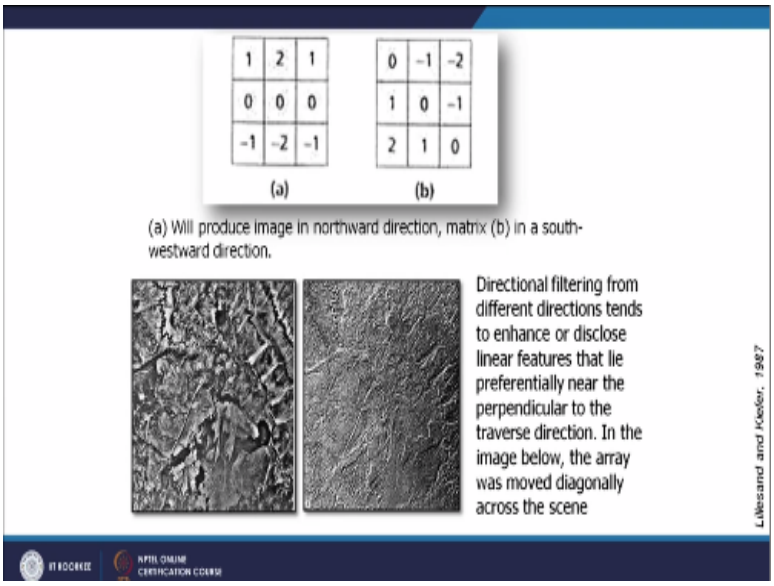

So like if I took this example of a will produce a good in North West at this is directional filter so in Northwest direction and whether they be in the southwest direction so this is a Southwest direction filtering, and this is how the result would be the directional filtering will highlight in the particular direction the way the filter had been designed, so here from different directions trying to enhance or disclose or disclose and we have features that life professional the perpendicular to the transverse directions.

In the image below the area was moved diagonally across the scene, so entire picture and this has been moved and as you can see that these features which are linear one all the boundaries have been highlighted very significantly in the direction every particular direction, now there are different ones so the concert was introduced about special filtering then there is no sort of limit and one can keep few more permutation or combinations between 3/3 or 5/5 so there is an example of that plus edge detectors.

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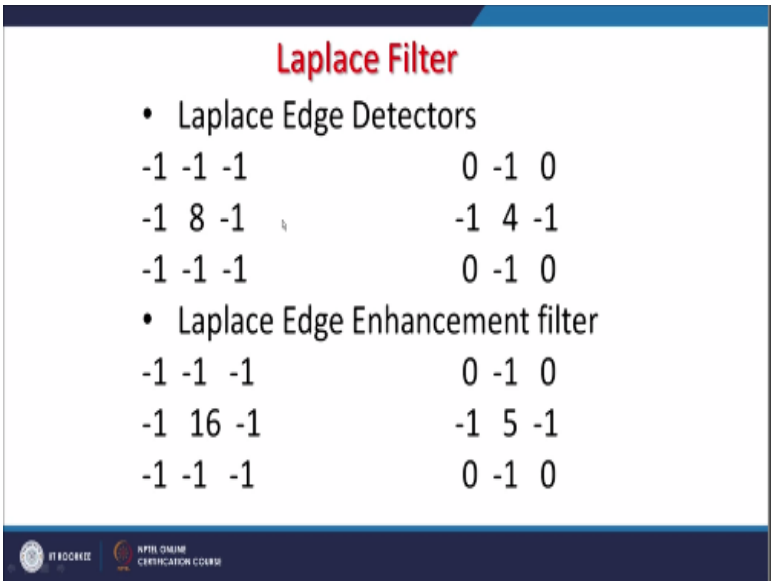

Laplace enhancement filters and different weightages are assigned to different cell values of factors.

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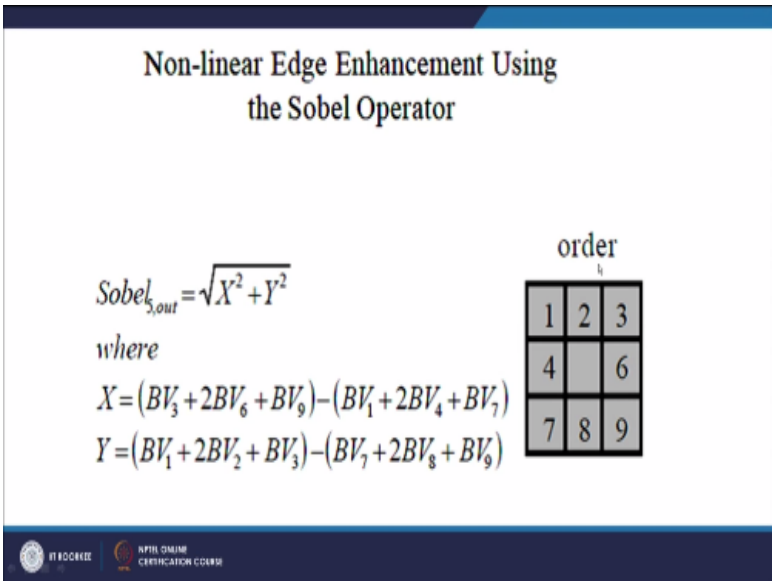

This is nonlinear edge enhancement using the Sobel operator, so this kind of calculation can be performed then of the output is like this.

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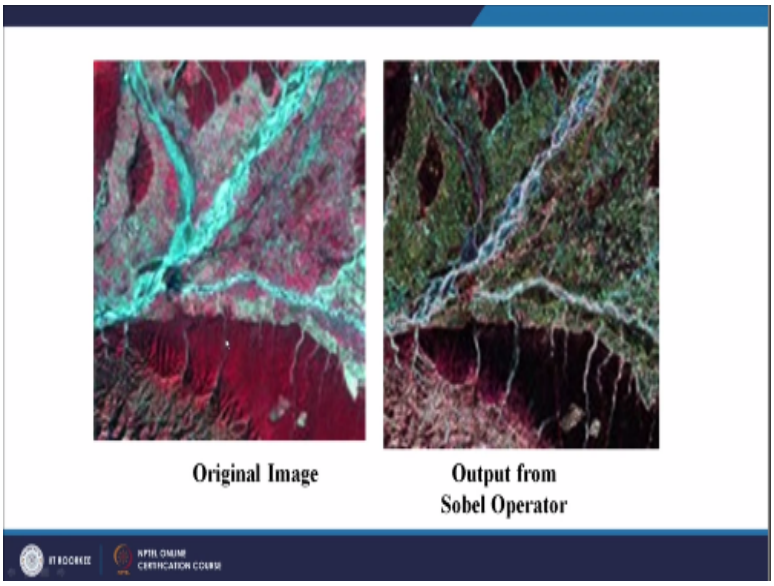

This is the original image after through sobel filter this image becomes something like this and the lights your filters are much more highlighted edges are much more clear as compared to original image.

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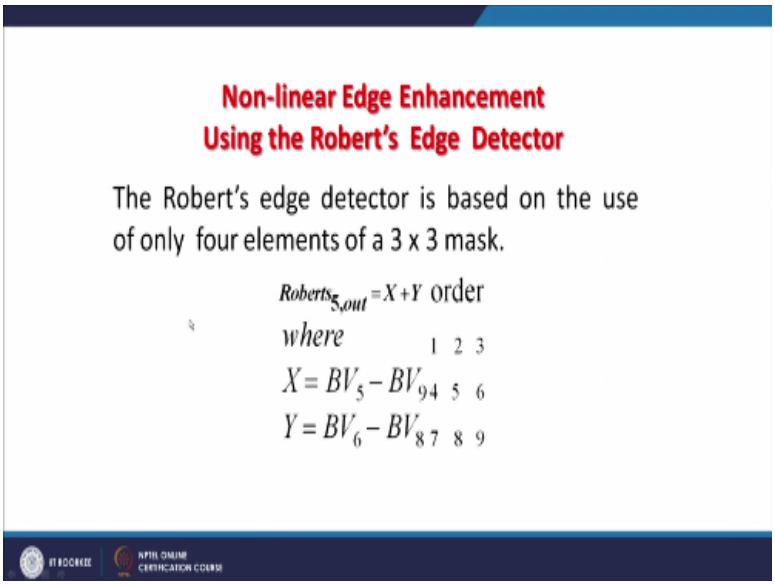

So there are various such a filters exist one can also design its own filter as per requirements and can use them in a digital image processing softwares, so this is an example of robots as filter and this and therefore I would like to mention here, that as I mentioned also earlier that there is a new standard filter which one has to apply on each image depending on the image type the filters which are present in damage my requirement one would imply a filter, so if I am looking for really features then I will go for low-pass filter.

And we will try to enhance the original features wherever if I am going for looking for local variations in the pixel values and I would like to highlight further then I will go for high-pass filter a variety of high pass filter a directional filter these are very useful, if you are looking the features which are particularly in the direction then accordingly filter can be designed we can be all digital image standard digital image processing software will allow you to design a new roof later or earlier vine filters like robot Sobel and simple and you know generic form of filters high pass low pass edge detection and edge enhancement filters so this brings to the end of this discussion thank you very much.

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