Remote Sensing essentials
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Lecture-25
Image Enhancement Techniques-2

Hello everyone and welcome to the next discussion, which is in continuation of earlier discussion which we had on image enhancement techniques that was the one. Now we are going to have the second one in this one and we will also have a demonstration through a commercial software about some basic techniques of this image enhancement. In the previous discussion of this image enhancement technique 1 we have mainly focused on linear contrast stretch, advantages and disadvantages and how these can be done.

Now we will be also discussing about non-linear contrast a stretch or enhancement. So here as you know that name implies that input and output data values do not follow the linear relationships and then that input and output are related by a transformation function which is y = f (x) and this increase or decrease in the contrast in different regions of histogram.

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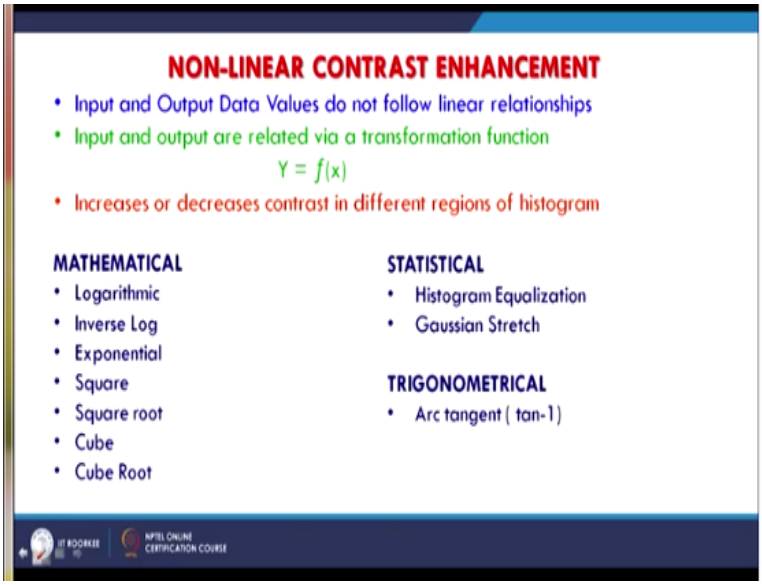

So that means we can rather than distributing the values in a linear fashion in throughout the full dynamic range that is in case of 8 bit scenario 0 to 255 we will choose the method which is based

on different mathematics as shown here. And we will redistribute things maybe based on the logarithmic, maybe inverse log, maybe exponential, maybe square, maybe square root, cube and cube root.

So there are different mathematical methods which have been implemented in nonlinear and some are also statistical methods also. And the one is the this histogram equalization, the very popular one and of course Gaussian stretch is there to you know, if a image is not distributed or image pixels are not distributed. Normally we can use this Gaussian stretch and then trigonometrically also that we can use arc tangent also for that purpose.

Now first we will go through a stretch which is gamma stretch and which refers to the degree of contrast between the a middle level grey values of an image, grey value why it is grey value. Because when we are talk about individual bands then we do not have colours values are distributed between 2 extreme colours that is black and white.

So **0** black is represented by 0 value and white is represented by 255 again this is 8 bit scenario and rest of the values are in between these 2 extremes that means they are grey values. So that is why the term grey values is used.

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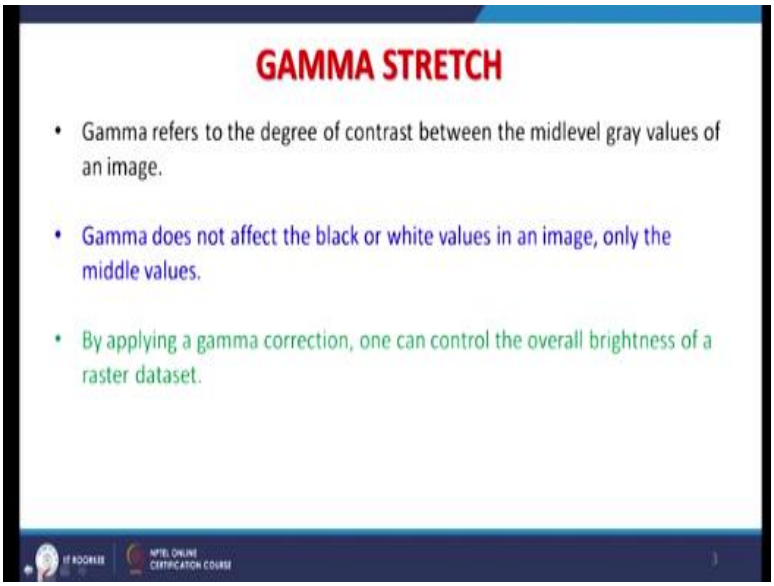

Now gamma stretch does not affect the black or white values, these extreme values it does not affect an image only mid level values it affects. And we will be also see through an image demonstration as well. So by applying a gamma correction one can control the overall brightness of a raster data set or a satellite image see the there is no standard formula or a standard procedure that once we get a satellite image, we must apply this kind of stretch it depends on image to image, even image of the same area.

But if it belongs to different seasons we may imply a different an image enhancement technique, so this one has to really remember. And that is why there are so many stretches are available softwares to perform. But depending on the image and how that enhancement whether it is sufficient or acceptable to a user that is also plays a very important role. Additionally, as you know that a gamma changes not only the brightness but also the ratios of red or green to blue when you go for a false colour composite image.

And or a colour composite image, gamma values less than 1 and decrease the contrast in darker areas and increase the contrast in the lighter areas and this darkens the image without basically saturating the dark or light area because it is not going to touch that extreme values.

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Here one example is given that original on the left side without any stretch and the middle one is 0.5 gamma stretch and then a apply 1.5 gamma stretch the result is. So the overall the brightness

has definitely increase but in the middle level, as you can see in the middle image that you know the darkness is there but you know the middle values are relatively darker.

But in the right which is the gamma 1.5 gamma stretch where not only the image has become much brighter there is of course, contrast is still there. But the darker values remain dark, brighter values remain you know bright, so that is the one of the advantages of gamma stretch.

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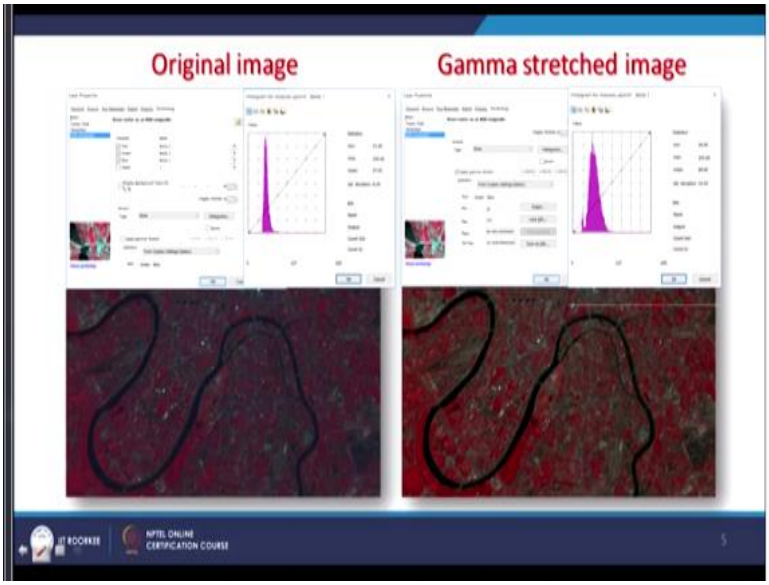

This is the image which I will be using also for demonstration the same image. So, this is the original image and when we use a software like today we are going to have on RGI software. Then this is what we will be doing that you can check also histogram and then this is the gamma stretch image and when you check the histogram see the distribution has completely changed. So from here onward, I go for this demonstration of this software.

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This is the image which is being displayed here and I can decide here for different type of stretches. So first we will what we have discussed is this gamma stretch and also related with the previous lectures discussions. So that when you double click on this you know in the table of content over that image then you see that one that it is coming there and then you can opt for that.

So here the option is already there for apply gamma stretch like here. Now you can choose a stretch type also, so I say I choose a custom type and apply gamma stretch I can give different values here also and when I go I can also see the histogram of my input image. And then I apply this one and see what happens to this image there is a slight change in the values or on the brightness of the image.

And if I go for some other kind of stretch like histogram or minimum maximum stretch basically this is the linear stretch again I can go for even gamma option also. So if I go for without gamma option and say that ok apply and just focus on the image and then now minimum as you can see that when the image was in gamma stretch it has the better brightness.

But when I went for minimum, maximum a stretch without gamma option, the image became again dark and lost the contrast. But if I go now this is the values are 1.5 and now I go for this one and I will see that the image has got brightness and things have really improved. There are a lot of options will be available here and you can definitely see those options and what I say to my students here that you play with these softwares, you spend more time on these softwares different options are available, lot of options are available lot of other.

Like for example, if I go for histogram equalization, then you see that the brightness should increase further, you know and it will create much more contrast. So histogram equalization creates more contrast compared to like minimum, maximum or other contrast, if I go for a standard deviation, I find is a very good you can change this n value here also. But and if I keep this apply gamma stretch on, then see the changes which would take place in the.

Now see this quality of this image, but this demonstration is against for that particular image. If you change the image, you may not get the same result. Because it depends on your basically on a input histogram, see after a stretch when you press this histogram. Now both histograms are displayed and that tells the entire thing which has happened during this stretch, see in the grey areas which it is showing is the histogram of the original image which you are seeing here.

Histogram of the original image and you can also get the histogram of the stretched image. And as you can see that it has been distributed throughout the available range and you say a 8 bit scenario. So for all 3 channels, this is for red, this for green and this is for blue. So all 3 channels the values are now spread, you can also check the values now like in red the values are with minimum values are up to now 26, maximum is 253.

In a green channel the minimum value is 28, maximum value has already reached to the extreme that is 255 and blue again minimum value is 41, maximum value is 255. So that is the advantage once you understand the histogram and how this image will be stretched and then you go for different options in a stretch. And after that also study the histogram what has happened, then things would be very clear.

But again I am saying that one thing one has to remember all the time that one is stretch one technique of contrast enhancement or image enhancement may not work exactly for the another image, even that image of the same area but of different season. So it depends on image to image, and there is one can say is a subjectivities there but what you are looking ultimately in the stretch limit what you are looking that how it has reached.

So anytime I go for none stretch, I can go to the original image like this, this was my original image. So this way one can do this stretching. In fact this is my now original image. So now, what happened I have not saved the image which I stretched does not matter whenever you save the image, generally you say only the LUT not the image.

And this is a LUT that is table basically look up table will be kept and will require only small space on your hard disk. But if I save this stretched image completely as a separate file then a duplicate basically it will occupy double the space as before. Suppose this image which I am displaying here is of a 10 megabytes then after again I save this image with a separate name without saving LUT only the changed image I am saving.

Then I will again occupied 10 more megabytes, so instead it is better always to save as LUT which will occupy just few kilobytes and your hard disk space will remain there. In different

softwares like in or RGIS or redox image processing software will save the entire project. And when you save the project, it occupies very small space, what the project does basically it stores the path of different data layers which are present in this table of content TOC.

And also LUT is another processing which one has done it, and that will occupy only few a maximum megabyte of space on your hard disk, the project.

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And the wherever your files are there, original they will remain as it is intact without any changes. That is the advantage of things saving in a form of project rather than always creating a save as and creating a new image file that is completely unnecessary. Now there can be a one argument here that if I want to next day if I want to do it in another software then how I will do it then these export import facilities are also available.

So you can export or import these project otherwise in a normal way, you can take these images save as and then open in some other softwares. So we go back again and if requires, we will come back to this discussion and we were here basically that gamma stretch has done, so this demonstration I have just showed to you.

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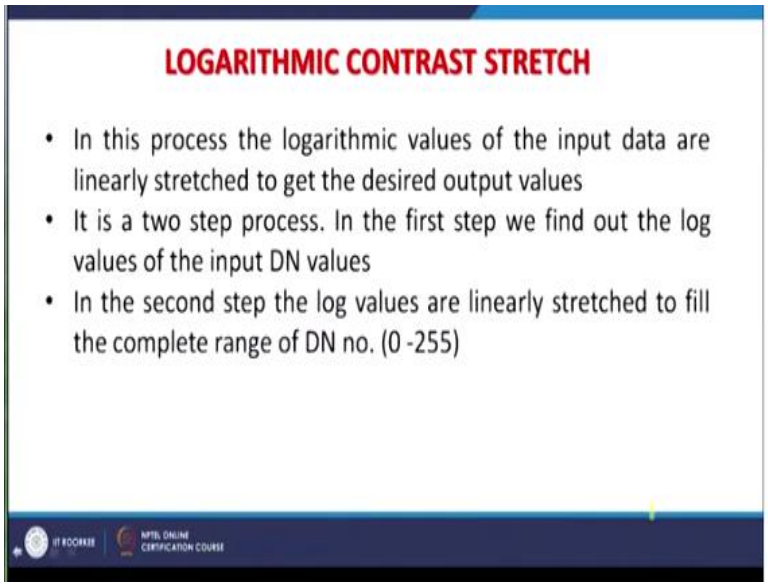

Now a logarithmic contrast stretch in this process the logarithmic values of input data are linearly stretch to get the desired output values. It is a 2 step process basically, the first step we find out the log values of the input DN values or pixel values. And then second step the log values are linearly stretch to fill the complete range which is available to us between 0 to 255. Logarithmic stress has greatest impact on the brightness values found in the darker part.

So and of the histogram on the lower, so it creates a you know brighter or create brighterness for the dark pixels, that is the advantage of logarithmic contrast, now it will depend again on image to image.

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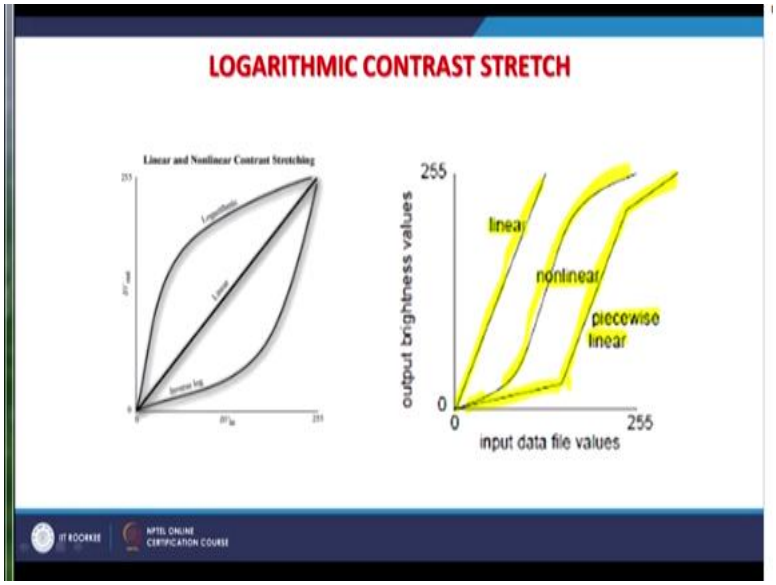

For example here both linear and nonlinear contrast stretch are being shown here. And as you can see that you know the normal a there can be a inverse log in the bottom also shown. And in here, when we see this LUT plot on the right side that input values are then in the middle you are having a nonlinear, this is the linear stretch and this is piecewise stretch that has to be done manually.

So I want a stretch of certain kind in this plot is a slope then I want a very high slope and then again slope. So in the first few pixels or first range of pixels starting which means say 0 to 50 I want this kind of slope, remaining values I want this kind of slope, so more brightness in the middle values. And then and higher values I do not want the same slope but maybe less slope. So

piecewise linear stretch is also possible nonlinear we are already discussing here and linear we have already discussed.

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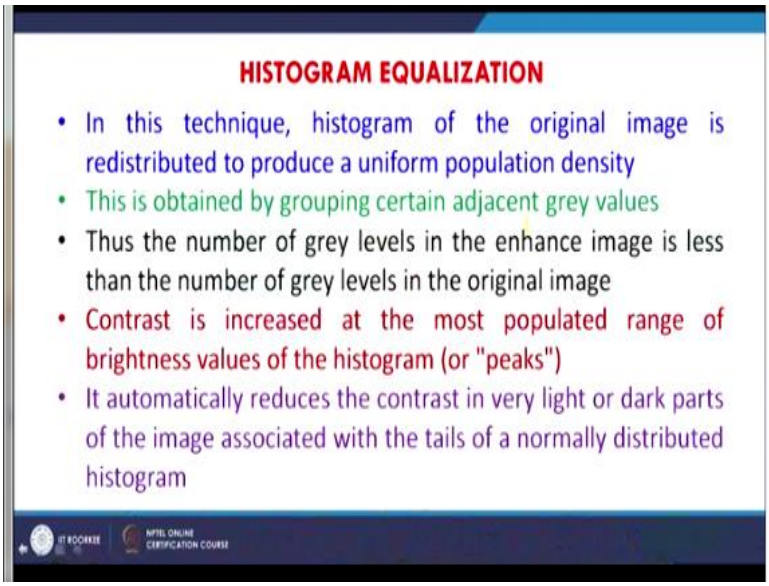

Now histogram equalization, sometimes back we also touched upon, so just for completeness I will go quickly from histogram equalization. I have already demonstrated through software also in this technique histogram of the original image is redistributed as you have also saw in the output, comparison between the input and output histograms. That these values are redistribute to produce a uniform population density as name implies histogram equalization, where more number of pixels are having the same value they are redistributed.

So that the values are distributed in a equalized fashion that is why it is called histogram equalization. So this is obtained by grouping certain adjacent grey values or pixel values grey values whenever we mention it means that we are talking a single band. And thus say the number of grey levels in enhanced image is less than the number of grey levels in the original image.

And this will increase the contrast as you also seen in the demonstration in the populated part, most populated range which is generally in the middle range and these are redistributed. So that is why you see the most contrast in the histogram equalization. So it also automatically reduces the contrast in very light or very dark parts of the image. So gamma was doing a little different stretch that means it was doing a creating brightness in the initial part in last part.

Here histogram equalization is zooming this rivers, it is doing in the most populated part it is doing the more contrast bringing more contrast in the image or more brightness also in the middle range values.

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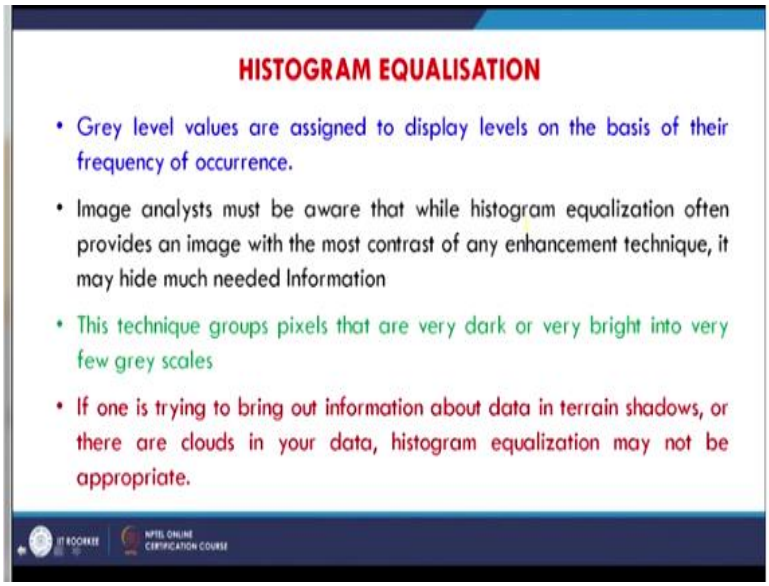

In histogram equalization, the grey levels or pixel values are assign to display levels on the basis of their frequency of occurrence. That how frequently these when we see large number of pixel that means the frequency is very high and that is why it is. So on the tail of a histogram the frequency is very less, so that is why the middle range values which are having high frequency or stretch more. Whereas the tail values which are having low frequencies are stretch less and by this way you create a histogram equalization.

So all this whatever we do through these any of these softwares we must be aware that histogram equalization also provides an image with most contrast of any enhancement technique. So if you want to perform want to have a more contrast in your input image then the best choice can be histogram equalization. However it may hide sometimes needed information, which is in the tail of your histogram or less frequency pixels.

And this technique basically groups pixels that are dark or very bright into very few grey scales that because while doing the redistribution it reduces their importance. So one has to remember

there, if one is trying to bring out the information about the data in terrain schedule. Because sometimes that is also there you know especially in the hilly part or hilly regions if you are having satellite images, the shadow part are always dark or there are clouds in your data.

So equalization may not be appropriate, so if you are having very dark areas or if you are having very bright areas in your image then that means then histogram equalization is not suitable. And this example we will again see here that this is the band 4 TM landsat TM band 4.

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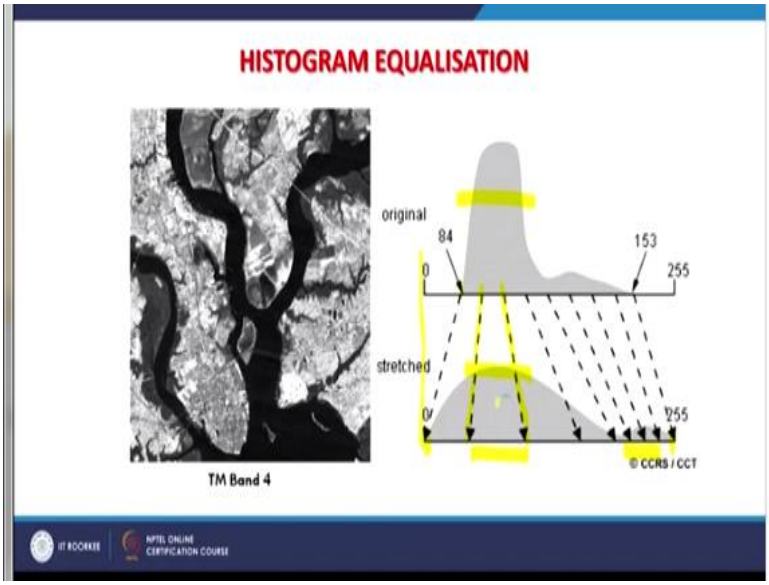

And it has been histogram equalize and you can compare the 2 histograms one top one is the original one and the bottom one is the stretched one. Histogram equalize, what you see that the height which was available here has reduced because of redistribution of the mid range values the available range which is 0 to 255. So earlier values were getting distributed only would mean the minimum value was a T 4 the maximum was 153.

Now minimum value is 0 and maximum value is 255 and mid range values have redistributed that is why these arrows are having more separation here. And these arrows are having no separation or other they are getting concentrated. And that means the mid range values has been a stretch and the because of less frequency on this y axis you are having basically frequency. So that is why this height of the shaded area has reduced that means it has equalize the image and you see the result here also.

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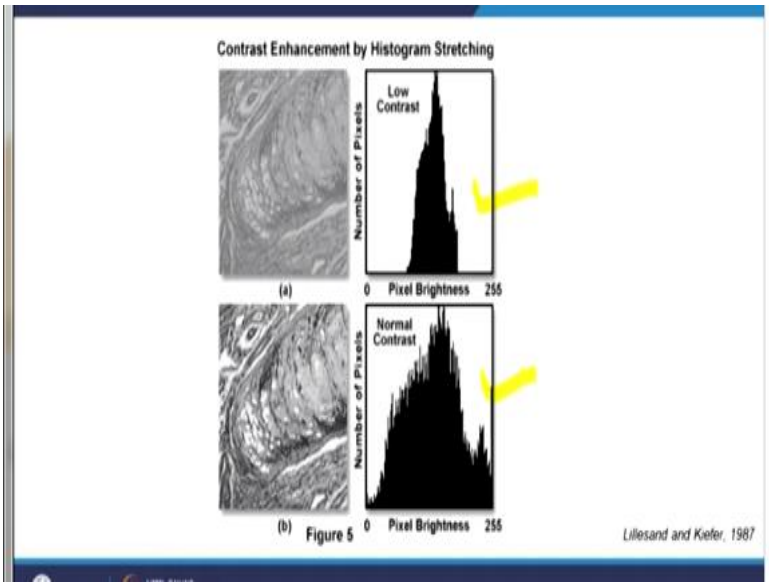

This figure earlier also we have seen in image enhancement technique 1. So this I have also demonstrated to you through the software when you are having low contrast scenario then this is the situation of this is the position of histogram. And when you are having a histogram equalization has also shown through software then it occupies the full range and frequency will also change.

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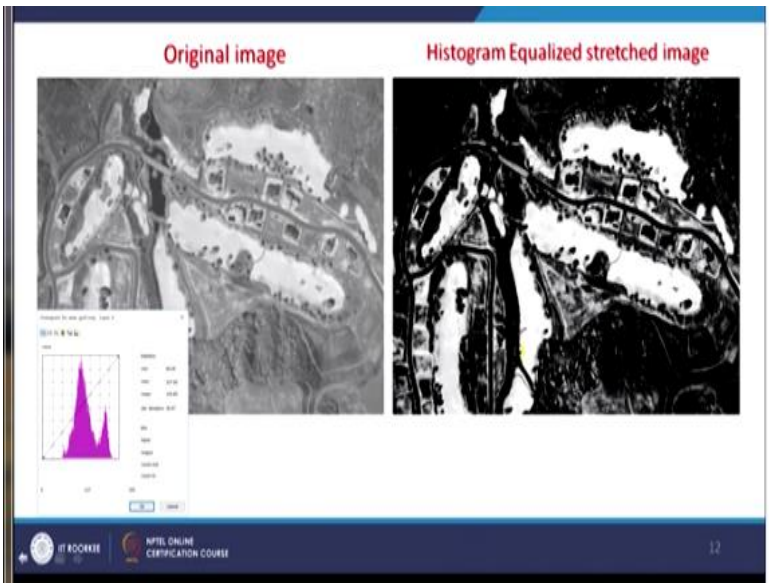

Here again original image and histogram equalize image, you can see the contrast the best possible contrast can be only created through the histogram equalization. So if that is required only constraint is, if in your image you are having 2 bright areas and 2 dark areas then do not go

for histogram equalization. If you are the values are in the mid range between the 0 to 255 safe between 100 and 150 or 200.

Then histogram equalization will create a very good output as you can see here, that the grey one is the input histogram and then we just do that one is the histogram equalize one.

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Again these properties when you double click you get these a stretch and then you choose appropriate option. Here histogram equalization has been chosen and this is what the results shown.

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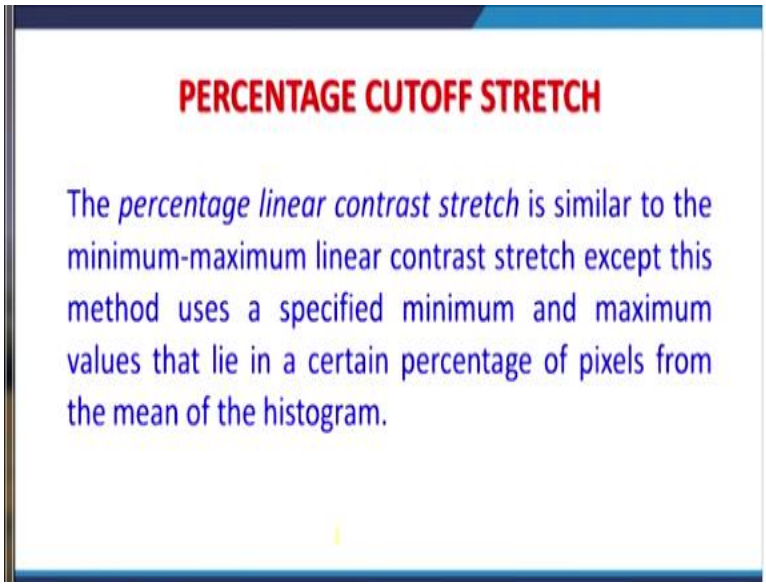

Now there are some other nonlinear techniques not that popular but still sometimes you require . For example there technique is called percentage cutoff is stretch you want to cut on the minimum and maximum certain percentage 5%, 10% and rest of the values you want to consider for contrast stretch. So this is what is called the percentage cut off stretch it is again though it is part of linear contrast stretch and which is minimum maximum linear contrast stretch, except that this measure uses a specified minimum and maximum values and that lie in a certain percentage of pixels from the mean of the histogram.

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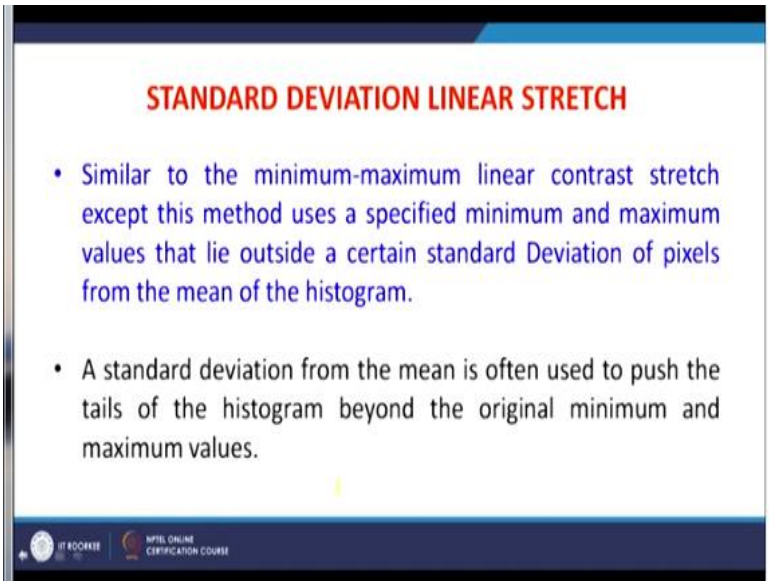

There are other a statistical techniques are there one is a standard deviation based on a standard deviation linear stretch I also showed you through the software as well. That similar to this again minimum maximum linear contrast except this method uses a specified minimum maximum value that lied outside certain standard deviation of pixels and that standard deviation value you can choose that 1 value 1.5, 2 whatever.

And a standard deviation from the mean is often used to push the tails of the histogram beyond the original minimum and maximum values. So it basically changes these tails of your histogram.

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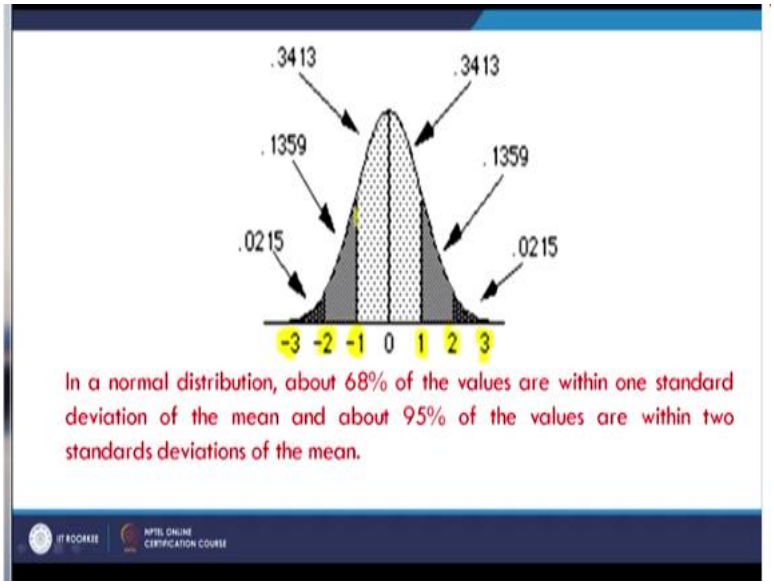

Like here, if I go for -3 this standard deviation 3 in both ends, then this is what I am going but if I go standard deviation this one 1 then this is how. So in a normal distribution about in this 68% of the values are within 1 standard deviation in this scenario also and in normal Gaussian distribution mean and about 90% values are within the 2 standard deviations, so 95% values are within 2 standard deviation.

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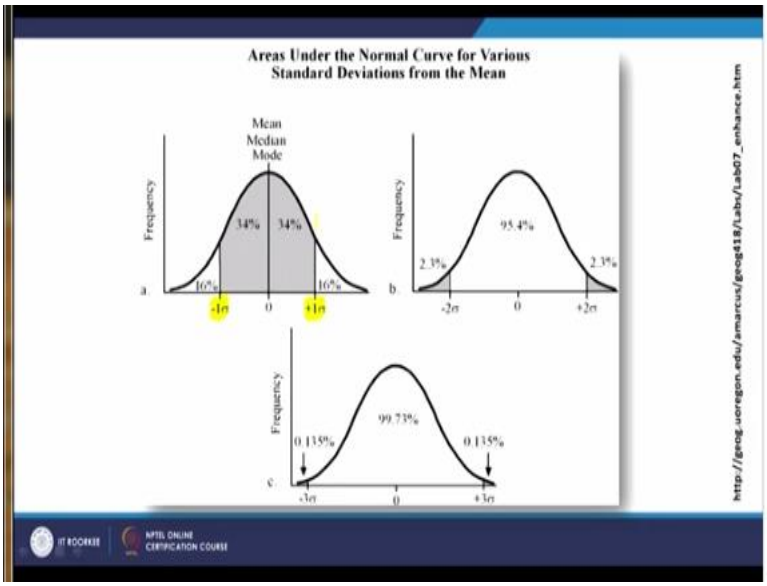

So under these circumstances if we say that, you know that this is 1 standard deviation scenario, so 34% values are on the left side of mean and 34% of the right side. But this is remember this scenario is only for a Gaussian distribution and generally normally it is hard to get Gaussian distribution of pixel values within an image. But nonetheless for our understanding, we can use these ones there are some examples here.

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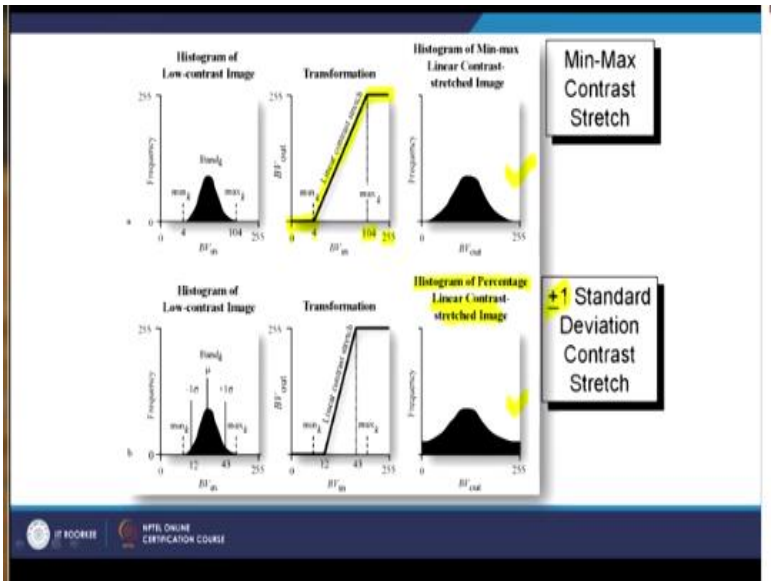

The first one is the minimum maximum contrast stretch example is here, simple linear contrast stretch in the middle the transformation that is look up also is shown here. That you know between 0 to 4 no an just on x axis things have move again on the higher side between 104 to 255 these values. So the value which is having 104 has been shifted to 255 the value in this example, the pixel value which was 4 has been shifted to 0.

And likewise I can create a contrast histogram minimum maximum linear contrast stretch but when I go for histogram of percentage linear contrast stretch. Then I am choosing certain percentage and getting things redistributed as you can compare with the minimum maximum, this is a little different histogram and 1 standard deviation contrast stretch has been created.

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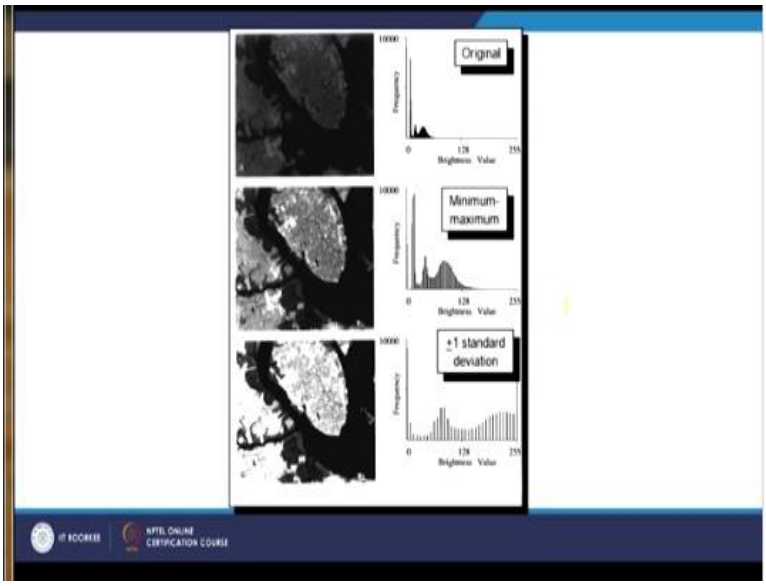

There are some other examples also the original image in the top minimum maximum contrast stretch is in the middle. And 1 standard deviation contrast stretch as you can see that the contrast more you go away means higher the value of a standard deviation you choose more the contrast it will create in the output image. Now whether that is acceptable to you or not that you have to decide.

So this one has to remember, because all these image enhancement techniques depend on image to image. So one has to be whenever you take any step for enhancement just make sure that these whatever the image it is creating is alright or doing over enhancement or under announcement. If it is over go back do the choose the less value instead of 1 standard deviation, choose 0.5 standard deviation if it is in under then choose the 1.5 standard deviation.

So there is a sort of iteration process nothing you know you do not have a standard flow chart by which you do it for all the images.

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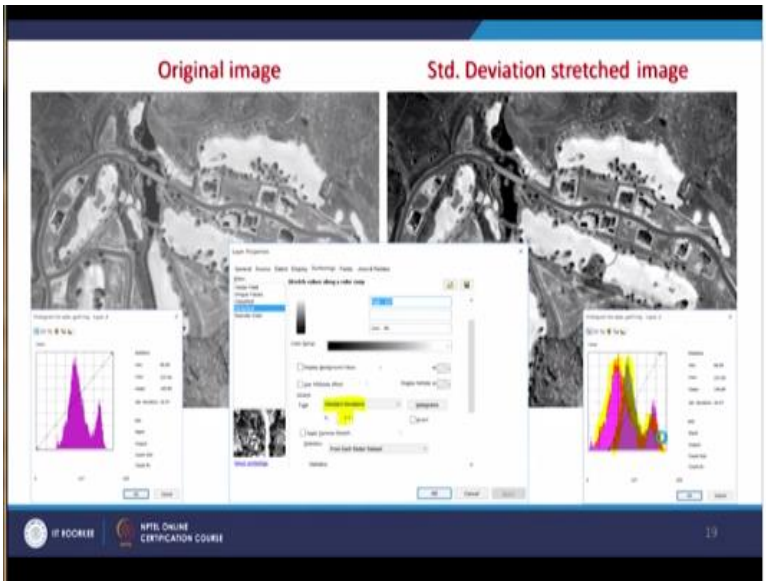

Again one more example standard deviation this image was, so this is originally image, this is standard deviation stretch image quite similar to the histogram equalization output. But if you put these 2 images one is a stretch by standard deviation and another one is a stretch by histogram equalization, you might see different viewing. Histogram equalization, compared to standard deviation will create more contrast in the image, where these options would be available here.

As you can see that standard deviation option you choose value I am choosing 2.5 in this particular case and demonstration and when you say ok, this is the result which you get and this is the redistribution of histogram. So the grey one here, the grey one here is the original image and the pink one is now distributed through standard deviation 2.5. So this brings to the end of this discussion about nonlinear contrast stretch as well.

In future also we will be trying to demonstrate in between wherever it is required through software. So 2 softwares we have already tried one was noncommercial and that is the DIPS digital image processing simulator I hope by now you must have downloaded and have started working on it. We will be again revisiting that software for other purposes like a special filtering and other processing.

Also today we have seen RGIS software which is a commercial software and quite expensive software, the license version is very expensive. And I would definitely urge you that whenever you want to use only the license version of the softwares. We maybe also having demonstration on some other commercial softwares too. But if it is required whenever it is required, we will bring that one to in our discussion. So this brings to end of this particular discussion that is image enhancement techniques 2, thank you very much.