**Remote Sensing essentials**
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**Lecture-18**
**Basic Image Enhancement Techniques**

Hello everyone, and from today onward we are going to discuss in next few lectures about different image enhancement techniques. So we will start with some basic techniques but before that I would like to discuss about different formats which are used with the raw data when they are supplied to us. Earlier as you know that when we did not have the optical media or through net then we use to get the data in magnetic tapes.

And if it is multispectral data then there were some well known formats are there and still you may find some data sets which maybe having one of those formats. So very briefly we are going to discuss about those formats first and then later on we will see basic things about image enhancement.

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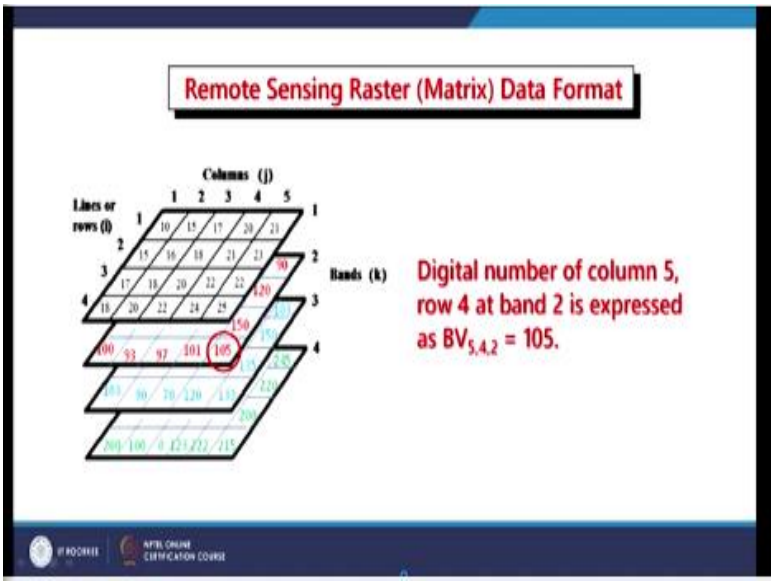


As you can see here a multispectral image is shown just a schematic or a sample. And if I want to retrieve a single pixel value then as it is marked here in this one is the corner one in the band 2 that is pixel value 105. And if these multispectral data is written in sequential form then the

retrieval use to be long process. So in many literature in books still you would find details about these formats.

Now a days after having everything on digital platform instead of or optical platform or on pendrive or through net. Most of the datasets which we are getting are now in band sequential format or individual bands are there. And the file formats are generally tif files, geo tif files, when I say tif file that is mean stacked information file format. And that is information about the file that is about the meta data is also attach with the file.

So that kind of format is called tif format and better format which also carries geographic coordinate that is called geo tif. So most of the data like for example if you download data of Landsat even past data or current data you may get the data very easily in geo tif format. And once if you get the geo tif format it becomes very easy because the geo referencing is not required and immediately it can be displayed on the screen and then enhancement and other processing can start.

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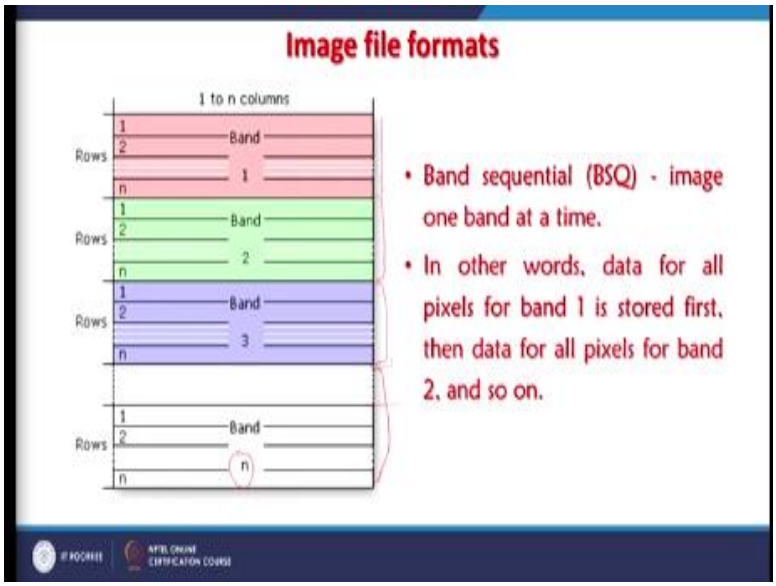


So we go for this image file format as for the sequential data as you can see that the example shown here the 4 band scenario is shown here. And they are in all sequence, so first all the information about all lines of band 1 are at the top like here. And then all lines of band 2 are in the second in the green color then blue color and then you may have several bands.

So this is n band and in between you are having some other bands. So band sequential this is called band sequential format image one at a time this is most common format nowadays. In other words the data of all pixels for band 1 are stored first and then for band 2 next and so and so forth till you reach the end of the bands.

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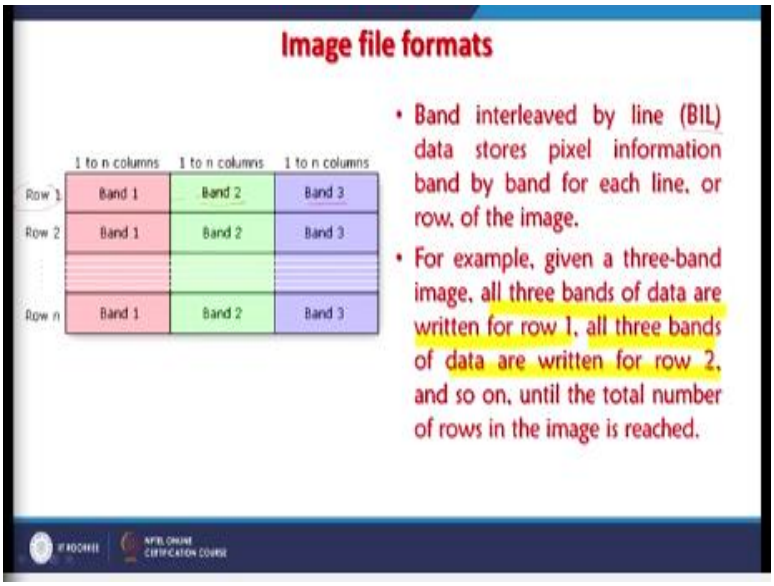


And like also you can have a different kind of format which is called band interleaved by line or BIL format in which as name implied that band interleaved by line, so what will happen that the first line that is the row 1 of band 1 will come first in the sequence. Then first line of band 2 is here then first line of band 3 is here and likewise you will get the data in the band interleaved.

So band interleaved by line format, BIL format data it is stores the data, pixel information, band by band for each line and for row of the image. This is very common also in some cases because when multispectral data is being acquired by the satellite sensors, line by line is scanned. So it is very natural or be fitting for that kind of format because the when the data is being acquired, it is also acquired all like first line of all bands.

Then second line of all band, so the data itself is coming in almost in the same format as the BIL. So therefore people also store for in this format the data and if it is 3 band scenario like here in

the left side image. Then as I have already mention that all 3 bands of the data are written in the row 1 then all 3 bands of the data are written in row 2 and for next line for next line and likewise.

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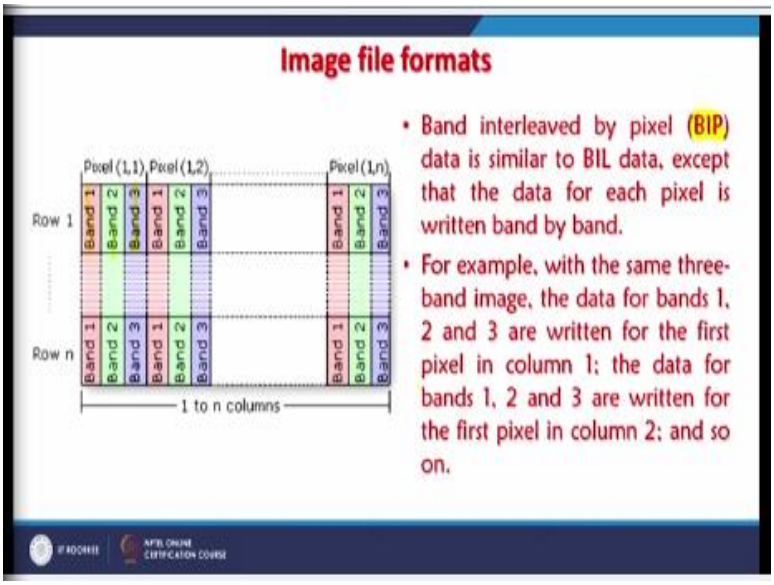


There is another possibility which is most uncommon format but still for certain applications it is there. Because there are certain applications where you need all 1 single pixel of all the bands at one time. And therefore another format which is called BIP format band interleaved instead of line band interleaved by pixels. And the data is similar except as I have mentioned that instead of line by line.

Now you are having pixels, so the like here example that row 1 band 1 first pixel is coming then row 1 band 2 first pixel is coming, row 1 band 3 first pixel is coming. And likewise you go till the end of the image, so if the data is stored like this then access also becomes faster. If I want to access a small portion of an large image and that image is stored in BIP format.

Then access of that small portion would become very fast, but if it is in the band sequence format or BIL format then it might take lot of time. So because retrieval efficiency purposes different format where all these 3 formats BSQ, BIL and BP where BIP were designed. Here also as also let me make you clear this was very common when we had the data storage on tifs not on random access devices.

After having these optical devices or other ways of storing the information then these constraints about these formats have gone. But still if somebody is working on old archives which many times in especially studies related with climate change or some change it extend study and the original data might be still in tapes or in these formats. And therefore knowledge about these formats and in case of image processing, digital image processing is very much required. So that is why I discuss first this part, now once the image has been acquired.

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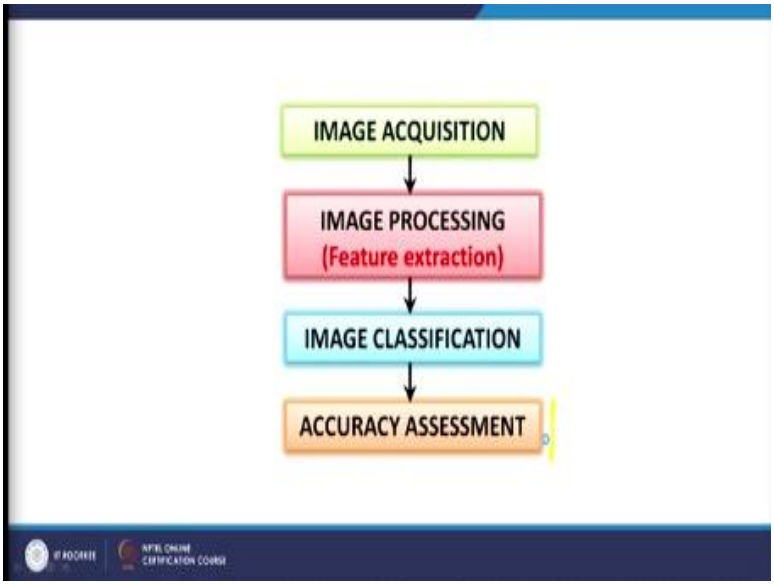


Then this image processing basically takes place and then later on this pattern recognition or image classification will also be there. And then accuracy assessment is also attempted of image classification because how good the classification has been performed that 2 can be assess through this step.

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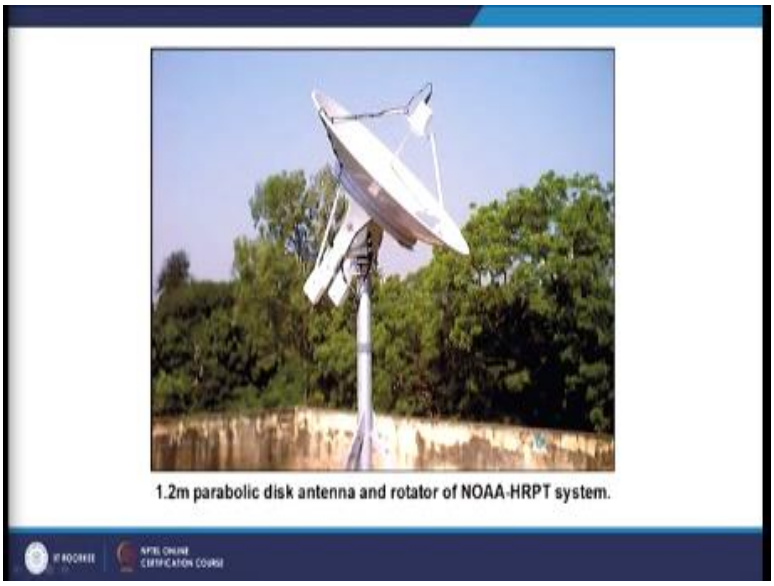


So first as you know that this few slides which I am going to show are repeat of earlier lectures. But here it they are relevant the purpose because image acquisition. So image from satellites, remote sensing satellites are acquired through the satellite earth station, this is external antenna of our NOAA AVHRR earth station. This is the internal setup, receiver is there and it is a PC based automatic system. Since we have in previous lectures we have discuss in detail about the functioning of this earth station.

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So I am not going to say much about this.

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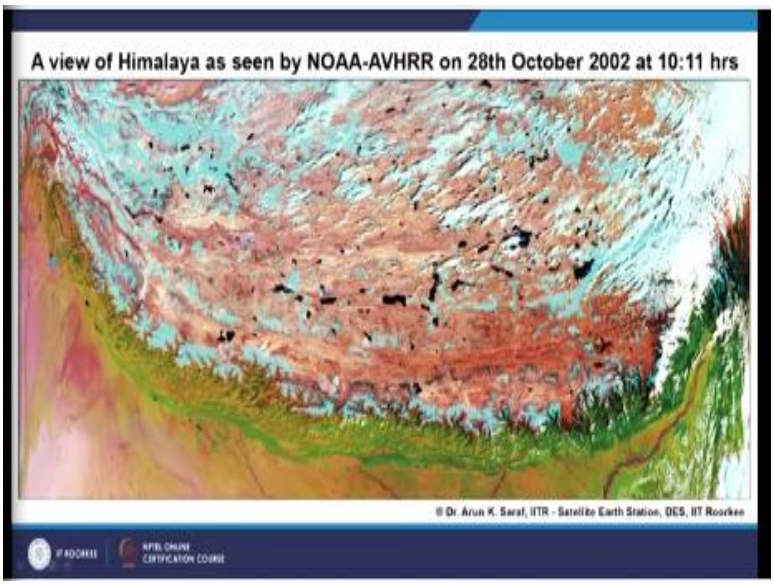


And because of relatively coarse or spatial resolution just in one go it can cover a wide swath and this is what you are seeing the entire Himalaya in just 1 image. This is not the mosaic of multiple images, this is just 1 single image acquired by the our earth station on this date and time. So of course it depends on the resolution but once the image has been acquired of course this is processed image, this is not the raw image.

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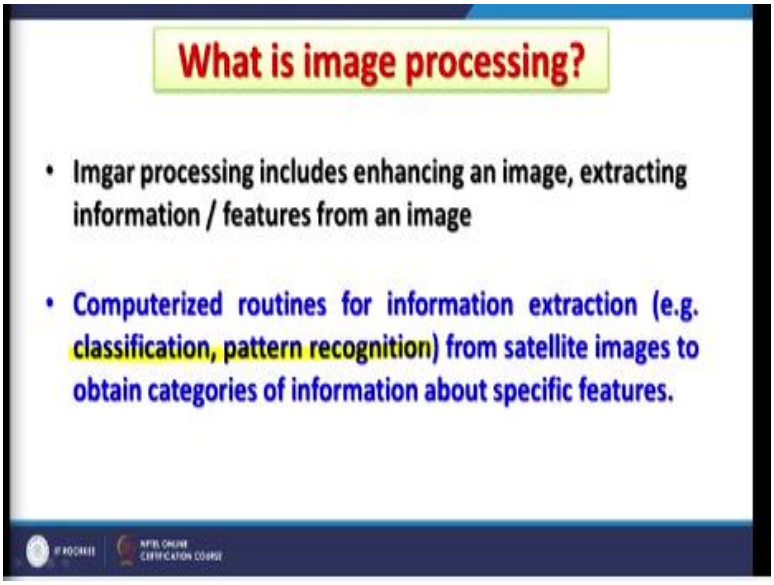


So the processing what this is what we are going to discuss, so image processing that includes the enhancing the image or image quality. So that the interpretability improves, also extracting information, feature extractions or object identification. That will come under the classification

of from an image from a satellite image or remote sensing image. So these image processing includes this these are of course because we are handling digital images.

So of course the there are in (()) (10:29) of computer, so therefore computerized routines for information extraction. And especially about the classification pattern recognition, object detections, maybe semi automatic or automatic manner from satellite images. And to categorize the information about a specific features, so that is also performs. So the first part is to improve the quality of an image before that we also require to remove certain errors which might be present in our satellite images.

For example radiometric corrections might be required, atmospheric corrections might be required or some systematic errors which might be there in the satellite images. Some of them we have already discussed some they might be we will be discussing in our future discussions. So those are also removed, so there are various steps and one it is not necessary that all steps up to be followed in a sequence, it depends on the input quality of image. So as you know that image quality and statistical evolution that is the first step which has to be done.

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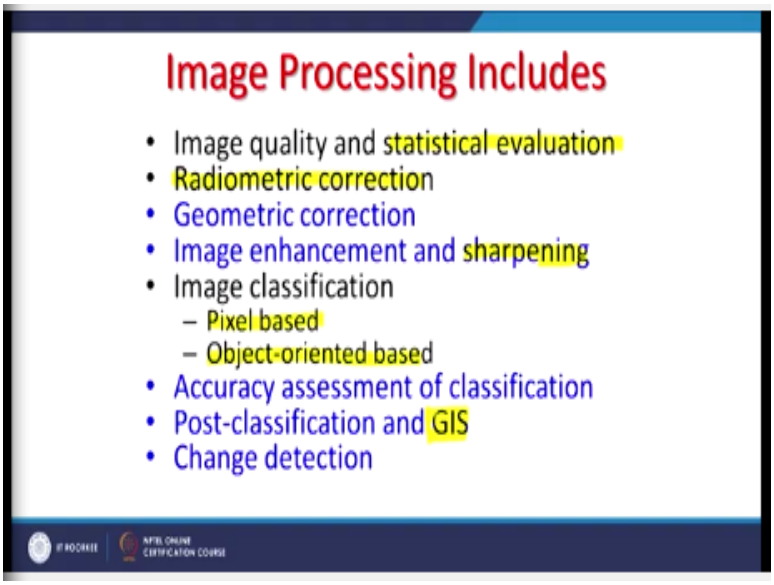


Especially the part statistical evolution usually it is done by looking the histogram of a particular image of or individual bands if multispectral images are being used. And also simple statistics what is the mean, what is the standard deviation and so on. So once I am having that information

then I can decide that which image processing or image enhancement technique I need to perform to improve the quality of my image.

So image quality matters for the enhancement, there might be requirement of radiometric correction. So that will be done any generally it is done by the suppliers themselves or the agencies. Like in India we are having NRSA and DC or maybe NASA or these web servers are also whenever they are putting the data. Because in order to remove radiometric errors from the remote sensing images lot of other information is required.

And that information might not be available to end users, generally it is available with the agencies or operators of those satellites or owners of those satellites. So therefore at our end we might not be doing radiometric correction but we need to know whether radiometric corrections have been performed on those images or not. Before we start using for our applications, geometric corrections of course as few minutes back I mention that if you are downloading geo tif image.

That automatically means it is geometrically corrected, but if you are downloading a simple tif image that may not be having geographic coordinates. Generally it will not have and therefore geometric corrections or georeferencing will be required. And that can be done using very these standard either digital image processing softwares or even GI softwares like RGIS or many other GI softwares.

Most of these softwares now supports the geometric corrections as well, image enhancement and sharpening these are through the spatial filtering techniques. Image enhancement, different image enhancement techniques are there, some are linear, some are nonlinear from simple to complicated one. It depends again you know what you are looking in the images and for what purpose you are going to use it.

But one thing I want like to make it clear here and later on when we will be discussing the classification at that time also I will remind this thing. That if you are going for ultimately for image classification then we careful of choosing appropriate image enhancement technique.

Because if you have enhance the image and then you go for image classification that might give you wrong results.

So it is better not to put lot of enhancement before classification, it is let the classified self identified different objects. And if does not then you can come back do the some enhancement and then do again classification, so that way. Now image classification, there are 2 broad types are there, one is the pixel based which is very common and also object oriented based classification have also been developed, they have been implemented by these popular software, so those can be also used.

And if you are going for classification then of course accuracy assessment, how accurately the classification has been done. That you have to check either ground tothet or by using some other already classified images of the same area. So that you can assess the accuracy part of classification, maybe post classification and integration of the images with the GIS that is also done.

Because nowadays hardly people are using satellite images in isolation they do the processing part first or classification part in the digital image processing software or even GI softwares themselves. And then along with other datasets, other themes, other layers they start using these satellite images as well, so that is why you go for GIS platforms. Change detection studies might be there, so you require a time series data.

Again nowadays this is the best time to do change detection studies why I said that best time to do change detection studies is because now since 1972 onward for almost entire group you are having satellite data. Because in 1972 is the first Landsat MSS data become available and since then now data is available. And this is all freely available, so if I want to now you know 1972 to this about 48 years or 47 years of data is now available.

And that give you lot of information about the climate change or things are changing because of some natural processes or some natural disasters or manmade. So all these things now can be

assessed using the long time series data of satellite data which is now has become available for all these kind of studies.

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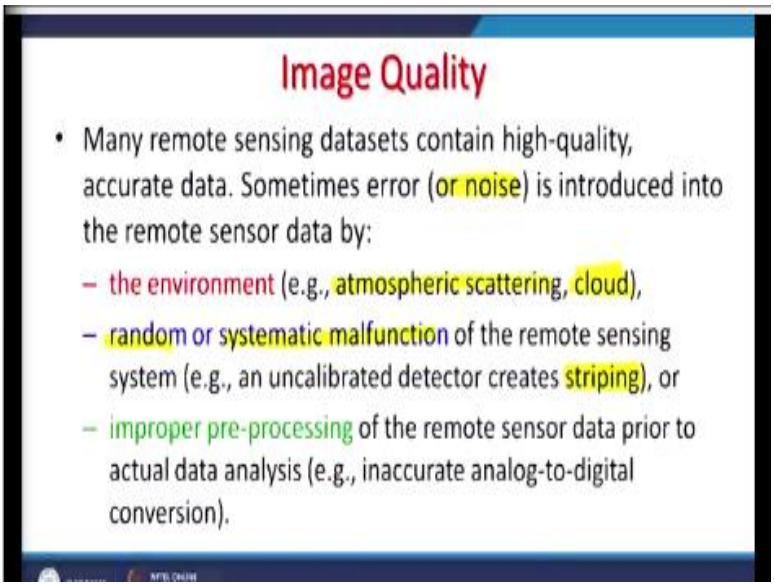


Further we discuss about this image quality and as you know that many remote sensing datasets already contain high quality accurate data when you download. And sometimes mosaics covering a large area or also available especially about the Landsat lens or mosaics lens which are already processed, georeferenced. They are geometrically corrected, radiometrically corrected and image quality has also improved.

So directly those images without going for any kind of processing can also be use for various applications. And but however sometimes there might be some errors, noise which you can assess by once an image is taken or downloaded from some sites. Once you displayed first spend some time and assess the quality of image, how good it is whether there are noises there are a stripes.

Because due to the bad sensor or bad calibrations all those things can be assed sometimes you may get the clouds or scattering. So your image might be looking very agy and that might be because of scattering effects which are taking place due to the environment or atmosphere and because between satellite and surface of the earth you are having atmosphere.

Sometimes you are having heavy conditions and would the image quality may not be good. So this has to be also assessed before you go for serious operations like classifications and other things. There also might be random or systematic malfunctioning of remote sensing systems, in earlier times these systematic or malfunctioning or random problems were more. But nowadays the these sensors, electronics and these devices have become really robust when you will get.

And such errors we do not see much except in Landsat-7 this problem came this is striping problem became so big. That become it became very difficult to use those images, so striping problems in the older datasets was very common. But it is not nowadays it is not much seen in different satellite images. If I talk about Indian remote sensing satellites hardly this striping problem has ever been notice.

So we have been since 1988 after having IRS-1A we did not have this kind of problem. The reason is because the electronic spot the sensors quality has definitely improved and lot of testing is done before sensors are send in the space. All kinds of testing is done for months or even years together and that is why these random or systematic malfunctioning are has become now rare phenomena.

Improper pre-processing, the pre-processing involves basically removing the errors. And if a proper care has not been taken then if I take that image go for image classification. I am bound to create wrong classification images or maps and therefore it is very much require to go through this proper pre-processing steps. Identify and identify the details of that image which you have got and that is the best way to do it is to also get dot met file MET dot met file.

And this is meta data file and whenever you download any satellite images generally these servers below also have corresponding meta file. And you this is not metology information, this is the meta data information. Meta data means information about the data itself, so you have downloaded a image say image name was image 1 dot geo tif or tif which is in geo tif.

And then you also will have a file image 1.met and this met will have all kinds of information related about that particular image. When image was acquired what kind of processing had been

done, what are the corner coordinates and so and so forth, do not avoid to read all these meta information. Whenever you download any satellite image because lot of free data is available nowadays, you must also along with that also download dot met file.

And also keep in records, in your records or in your hard disk about these meta file because they are they become very important when you go for classification or any kind of reporting. There you have to mention that on which date of which sensor, which satellite this image was acquired, what kind of processing was done by the supplier itself and what kind of processing you have done through or breathing should be mention.

So these problems might be there if care is not taken, now inaccurate analog to digital conversion. Again when our sensors themselves were doing all this exercise there were some issues about this conversion from analog to digital.

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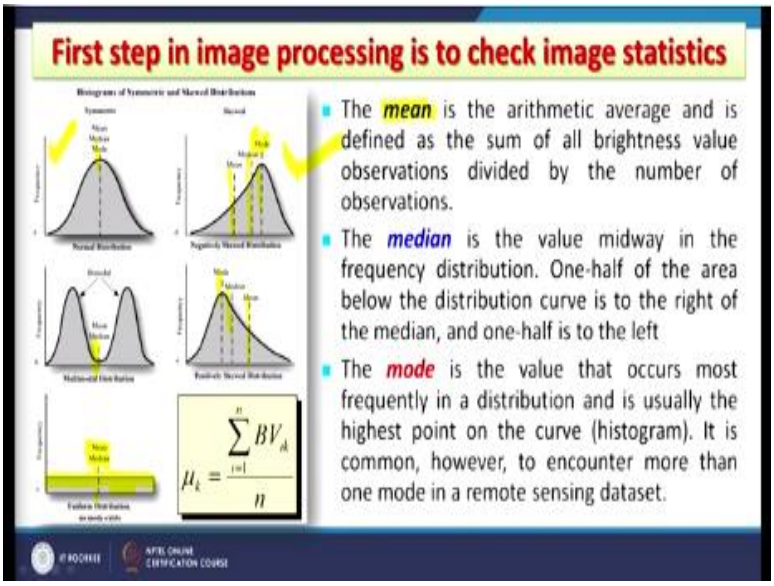


But as I am mention now our sensors are become very robust, very advance and therefore such problems are not there. Now first step in digital image processing of satellite data is to check histogram and simple statistics. This is what I am taking one example here, that when you display a histogram ideally we expect that histogram should look like the first example in a well shaped you know.

And but this is not normally you get in a natural images unprocessed image. Normally but you expect that there should be well shaped or Gaussian distribution. But it is not there, you may get a image like this that maybe of this might be possibly there of a snow covered area or might be in a desert conditions, a histogram of that image may look like this.

So if you see the normally distributed or Gaussianally distributed well shaped histogram there mean, median and mode all are coinciding all are same. This is ideal condition which is not which is rare in any of images which you download or get raw images I am talking. This is possible scenario as I have said the areas which are having high (()) (24:54) high reflectance maybe in a snow covered areas, maybe in desert conditions.

You may get this bimodal or multimodal distribution in this example bimodal and therefore mean and median are here. And 2 lobes are there, entire data is distributed in 2 this scenario might be in a area where you are having 2 distinct maybe rocks 2 distincts forest or vegetation or agricultural land or maybe at coastal regions also. Where half of the image is having land part, half of the image is having the sea part.

So this kind of distribution might be there also you may have just opposite to the this top right you may have a skewed image skewed histogram which is in the beginning of the image you are having maximum frequency in the lower among lower pixel values as is shown here. So mode is here then median and then mean, here is mean is coming first then median and then mode.

If it is uniformly distributed again this is a very rare thing except in you know stand still or very calm ocean conditions or in a very desert conditions where you do not have any features at all almost feature less desert. Then you may get a histogram or pixel distribution something like this completely flat part. So this is very much because once you have seen the histogram, analyze the histogram.

Now you know what kind of processing would be required for my image, so that tells the future step for image processing. Now here the mean which by mean mention here the mean is the arithmetic average and is defined as the sum of all brightness values that is pixel values,

observations divided by the number of observations. So here this is what the mean is derived from a satellite image.

Median is the value midway as you can always see here median, median, median and median here is the value median the frequency distribution. Because on the y axis you are having frequency on the x axis you are having the pixel values. So one half of the area below the distribution curve is to the right of the median and the other half on the left side of the median.

And mode is the value that occurs most frequently in a distribution and usually the highest point on the curve. So as you are seeing in most of these examples that is the highest point here. So these things though these are simple things you might have gone in a simple statistics but it is necessary to relate.

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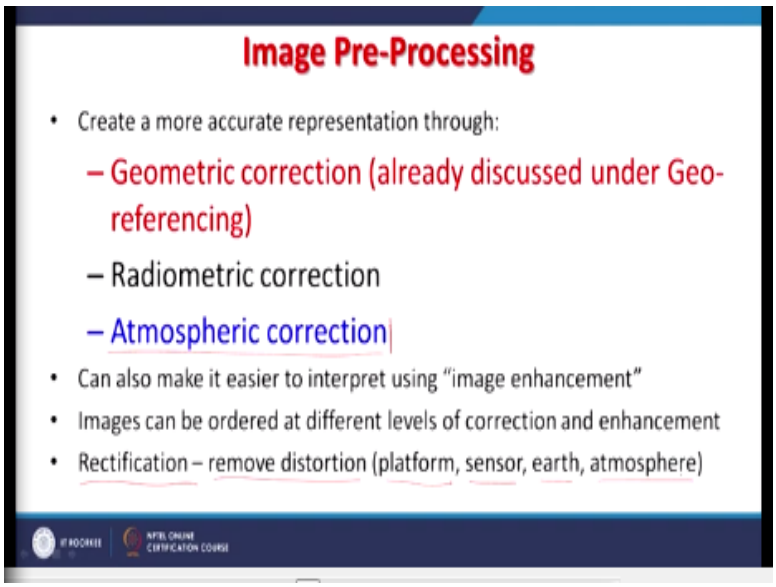


And remind about these statistical parameters which will allow us to understand what kind of processing is further required to improve the image quality for better interpretically. So in image processing now we go for geometric correction very briefly which will be discuss not already discuss sorry for this wrong typing here. This will be discuss as a separate topic in georeferencing then radiometric correction.

Whether they have been already done, generally it is done by the agencies, atmospheric corrections are not by agencies. If it is very much required we must do it but if say complicated task, so one has to be prepared with lot of input data if you are going to attempt atmospheric correction. We will have a separate treatment for atmospheric correction in later discussions.

And also it is basically main purpose is to improve the quality of image, so better interpretations can be performed, that is the purpose of image enhancement. And as like in India you can order images asking that please perform these corrections before you supply. Of course there will be some extra charges, suppose you go and say that I want geometrically, radiometrically and atmospherically corrected image for a certain area.

Then agency will do it, they are having their standard you know procedures, techniques by which they will do it and supply it but it will be costly affair. Rectification, again rectification is also sometimes for geometric correction rectification term is also use. But basically rectification means removing the distortions which might have been introduce by the platform or might be the sensor, earth curvature or atmosphere.

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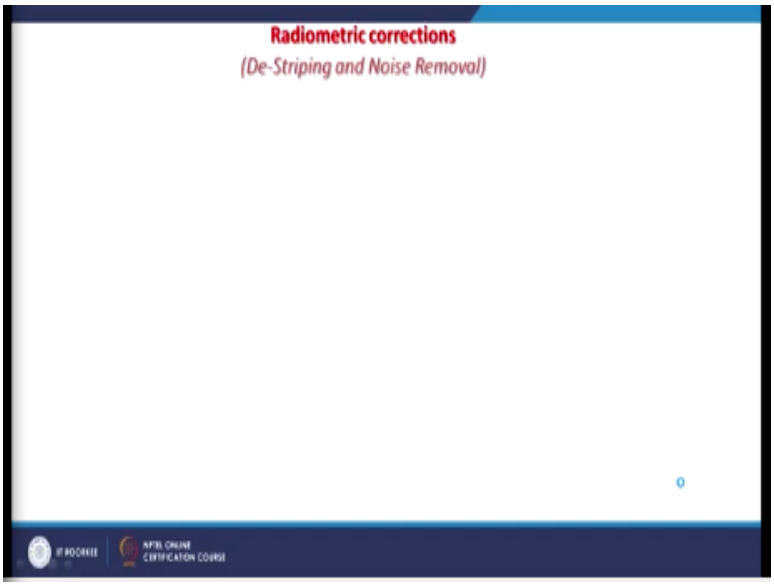


So these rectifications are required, now so we will go one by one all kinds of corrections which are required. So first is the radiometric corrections, radiometric correction is a pre-processing step method to reconstruct physically calibrated values by correcting the spectral errors and

distribution caused by the sensor. These striping will occur only when use CCD in a sensor or not perfectly calibrated.

And therefore they will produce de-striping phenomena as you can see here. So or we say noise removal also, one can call it but noise when say it is a random kind of thing.

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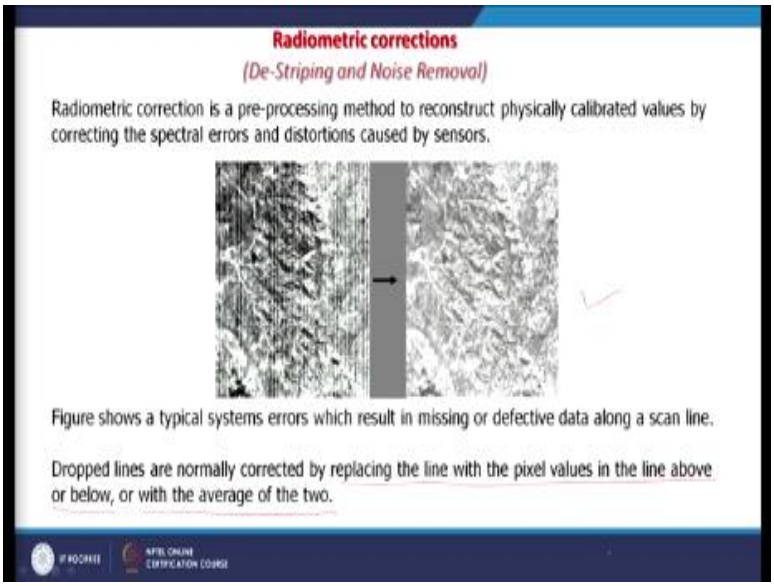


These striping is a systematic error due to the poorly calibrated sensor, sometimes on the ground everything was done perfectly alright. During launch or after certain years of operations, the sensors may go bad. So you may have or they some may start underperforming and therefore you may have this striping affect too. But if it is not too much like in this example then using the surrounding pixel values adjacent pixel values.

These striping affect or striping affect can be removed and these then you will get an image which does not have now these striping affect as on seen on the right side of this image. So this is a typical errors and it is possible to some extend to remove by using the surrounding values and taking their average and giving to those pixels which are under these underperformance of individual sensors.

And these dropped lines are normally corrected as I have just mention replacing line with the pixel value in the line above or below or with the average of. So it depends on for what purposes you are going to use images and but it is possible to do.

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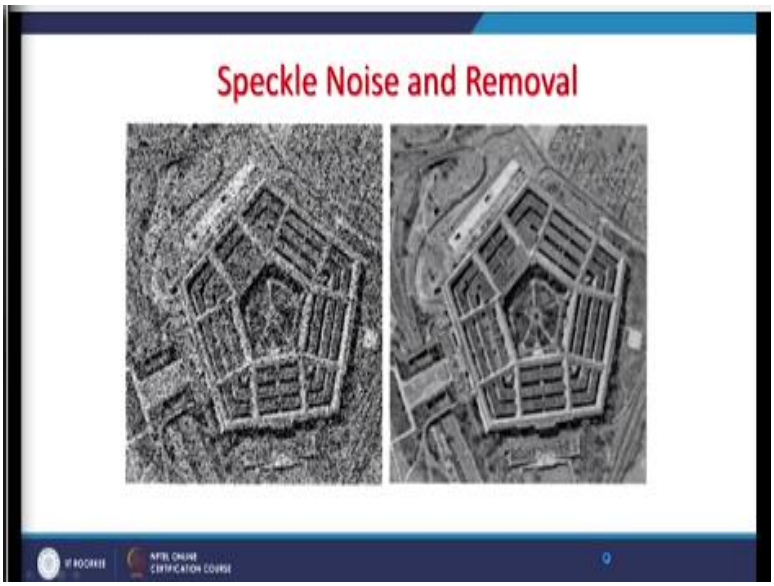


Now the noise part, noise generally speckle and these speckles as shown on the left images can also be remove again employing almost the same method as for the dropped lines. That means now looking the surrounding values and taking their average and giving to the that pixel which has got this black dot or black dark perform or low perform is by the sensor.

So by doing that exercise one can achieve this one, systematic errors are easier to remove none systematic errors making noise is not that is easy. And still that the output may carry unless you go for large area search radius and that may reduce the quality of image. That will that may reduce the sharpness in image.

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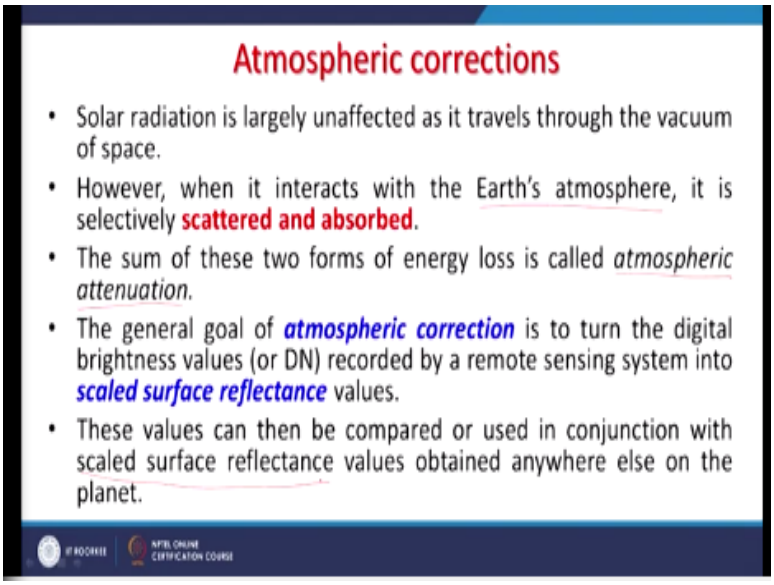


That will make the image more smoothen but may not be very good for certain applications. Otherwise generally if there is no choice I have to use that particular image because that belong to a particular date and I needed then that is the way to remove that noise. Generally noise striping affects can be seen but noise generally is not common in normal remote sensing images except in the microwave or radar images noise is a very common phenomena.

Now atmospheric corrections, atmospheric correction is the basically because it happens when this it has the reflection or emitance has to travel through atmosphere to the sensor. So solar radiation basically if I am talking data in images generally which we use then solar radiation is rarely unaffected as it travels through the vacuum of a space. But in natural condition we do not have the vacuum, so it has to pass through the atmosphere.

So when it interacts with the atmosphere, earth atmosphere is selectively scattered and absorbed depending on the size of particles or gases which are present in the atmosphere. And this is very dynamic, these are particles and gases are not permanently located in certain heights or depth of in a space. So this is very dynamic system and depends on image to image basically or day to day conditions of atmospheric conditions.

So these some of these 2 forms of energy loss which is one is scattering another one is absorption is called atmospheric attenuation. And this attenuation can reduce the quality of an image, if you

compare the image is of earth with images of mars, mars taken by various satellites even our Mangalyaan. Images of mars are very clean, very clear the reason is because mars is does not have much atmosphere at all.

Say very thin atmosphere it is having and therefore it is perfect for remote sensing because in between there is no atmosphere, you will not have atmospheric corrections and images of . You get images of very high quality even the sensor may not be as good as for earth we are using. But because of the presence of earth because of a scattering and absorption affects by the various gases, various particles which are present deteriorates our image quality due to atmospheric deterioration.

And our aim in atmospheric correction is generally to remove that or minimize may not be removal is may not be possible all that time. It is too difficult also because we need to have lot of input data and for that particular moment of time when image was taken. So someone has to collect the data, now all these models which are used for atmospheric corrections or techniques which are used requires those kind of inputs.

So completely removing atmospheric effects from satellite images of earth is not really possible. But none the less we try for that thing. So that these the atmospheric correction is in turn the digital brightness values recorded by remote sensing system into a scaled surface reflectance values because of this one. So these are not basically true brightness value but they are distorted due to the presence of atmosphere.

And these values can then we compared or used in conjunction with scaled surface reflectance values obtain anywhere else on the planet. So if a one would like to do it almost you know 100% or near 100% removal of this thing. Then you require standard values which have been collected without having atmospheric distortions. And if you compare with these values if you use those scaled surface reflectance values then it becomes easier to remove atmospheric distortions from the satellite images.

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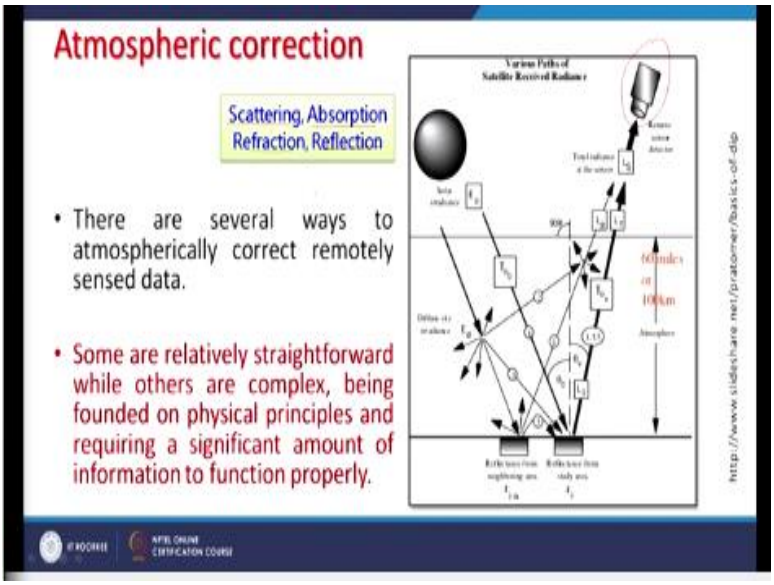


As shown here that scattering absorption, reflection, refraction all these things are happening. And this all is happening between 100 kilometer from earth up to the top layer of atmosphere. Sensor is much above 850 kilometer but in between the energy has to pass, reflection or remittance energy has to pass through this atmosphere. And all kinds of these phenomena attenuations scattering, absorption, refraction, reflection will occur.

So therefore it is little complicated to isolate different these contributions of these attenuation parameters from to in order to remove atmospheric distortions. So there are those several ways of atmospherically corrected remote sensing data. And some are relatively straight forward we also call brute force kind of thing in a very simple way you can just remove assuming that same should have been like that only.

That we will also discuss the straight forward way, being founded on the physical principles and requiring a significant amount of information to function properly, if you want to go for more sophisticated.

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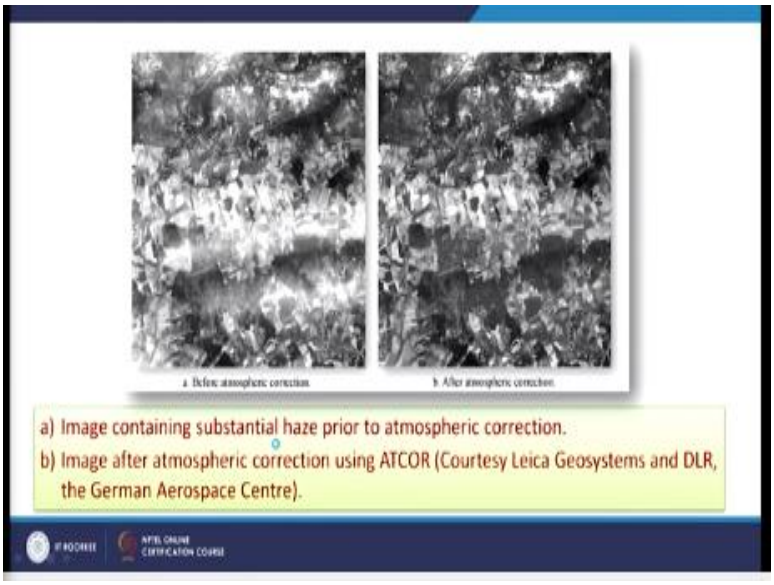


Now here I am giving one example on left side you are having an image which is suffering from atmospheric distortions. And as you can see that because of presence of different particles and gases within the atmosphere you are seeing that is middle part is relatively bright and then you know top part or bottom part is little darker. But when this correction was performed then the middle part is no more that much bright or these top part and bottom part are now not much different than the central part.

So in because these might be having some in the left image this might be suffering from distortions atmospheric. So if like substantial haze, haze is nothing but the scattering happening within the atmosphere. And that can be also be corrected to some extend and after this image correction this there are different models in each software company or organization they are having their own models.

Depending on basically the requirement of atmospheric correction completely depends on for what you are going to use satellite images. If you go for very quantitative analysis of remote sensing data, satellite images then atmospheric correction is must. But if you are going for qualitative applications, qualitative assessment of satellite images then probably the you know the straight forward methods of atmospheric correction that is sort of linear enhancement through linear enhancement one can achieve that we will be also discussing later.

So image enhancement as also discuss earlier is a improves the interpretability of images, uses of images by increasing apparent contrast among various features. So different features present, objects present on an image can be distinguish can be discriminates distance very easily.

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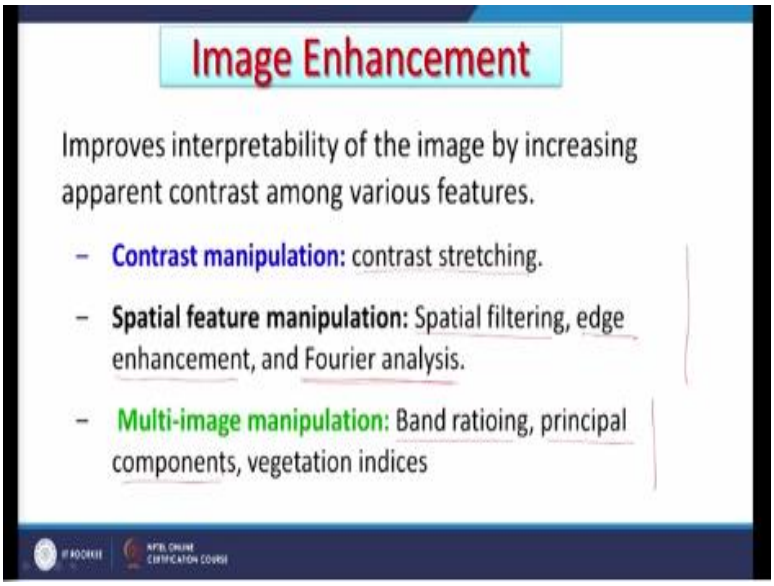


So one technique is called contrast stretching or contrast manipulation very simple technique. There are spatial feature manipulation techniques which are like spatial filtering, edge enhancement that is also part of special filtering or maybe smoothening the image or instead of special domain one can transform the image in the Fourier domain or frequency domain and then can do the corrections and or you know filtering.

And then again transfer backward transformation from frequency domain to spatial domain by going through this Fourier analysis, so that is also done. Now multi image manipulation these 2 can be done on single image or multispectral image but these multi image manipulations are done on multiple when you are. Generally we are handling multi spectral data, so we can also perform band ratio.

Sometimes can be get very good results because now 2 bands information are involve here. Sometimes you can use principle components, if you are having too many images and you want to you know collect grab the maximum variance present in different images. Then the principle

component can be one of the techniques which we will be discussing is very good to get a better color composite.

Maybe there are few vegetation indices are also there, so that can be also use these will be perform on multi image when you are having multi spectral images.

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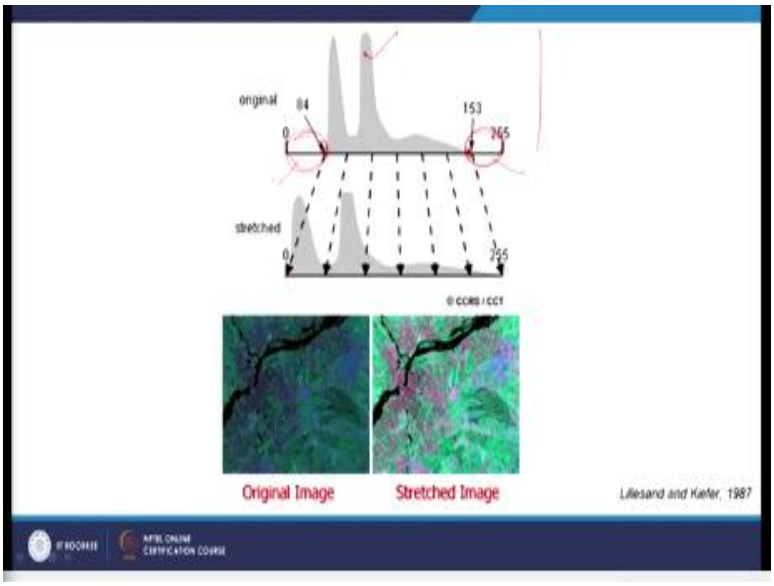


Now one example is here which we see the on the left side on the bottom you are seeing the original image. And on the right side which is contrast stretch image is now as you can see looks much better as compare to the left image. Because left image is it has not been you know contrast stretch or brightness or contrast has not been improved on it. If you see the original histogram as I mention also whenever you use a raw image first see the histogram, simple statistics.

And then move for choose the appropriate image enhancement technique. So if you see the histogram what we see that the distribution is between 84 to 153 instead between 0 to 255. Ideally what we expect well shaped distribution, a Gaussian distribution all values are varying between this full dynamic range between 0 to 255. But in this particular example the values are varying between 84 to 153 and this is a bimodal distribution as well.

And as you can see that there are certain areas which are having maybe the water bodies, maybe the shadow areas which are having low pixel values or appearing as dark as compare to other areas which are appearing. Bright and this is the second peak in histogram is representing though brighter areas. So what the quickest way of removing atmospheric distortions there might be haze and other affects might be there in the left image.

So the quickest of you know straight forward way or removing that thing to do the linear contrast stretch or linear enhancement. And that can be done by pulling this bottom of this histogram first log or first peak. That means shifting 84 value to 0 and 153 value to 255 and stretching to full extent like that. And that is why it is contrast stretching and ultimately what we are improving in the image is the contrast.

And this is what you see on the right side image and when you see the histogram of this right side image, the contrast stress image. Now you see that the now it is occupying the full range, full dynamic range available it is a 8 bit scenario though image is colored what single band example is given in the histograms. And this is what you are seeing that now pixel values are varying between 0 to 255 instead 84 to 153.

Because this is the space or dynamic range available for us to display our images and original image was using only between 84 to 153. Now this contrast stretch image is using the full dynamic range between 0 to 255. And therefore you are seeing results were and I mention about this quick way straight forward way of removing contrast atmospheric correction.

There might be because of a some absorptions these areas you do not have for this part of histogram you do not have pixel values because of absorptions. And there are areas which might be due to scattering effects you are not getting values here and due to your absorptions you are not getting values in this range. So by stretching these values from 84 to 0 and 153 and remaining value accordingly.

Then you are forcefully removing here the absorptions and here you are removing the scattering. So this way the atmospheric attenuations can also be removed but this is a very hard way of

doing without having any input about the atmospheric conditions. Just looking the histogram and if they are not distributed in full dynamic range we are pulling them and distributing in the pull dynamic range by removing these 2 major effects of atmosphere that is scattering and absorptions, so that way it is possible .

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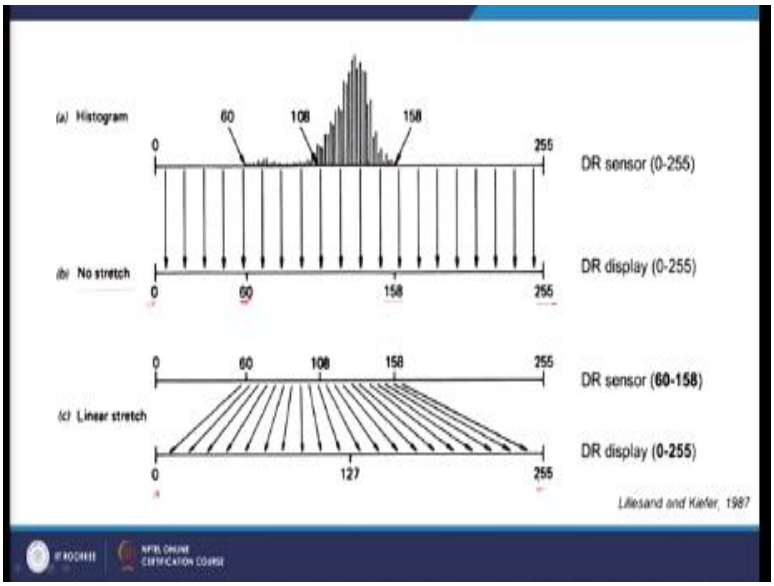


Another example is here that is values are distributed between 60 to 158 and I can stretch these values this simple linear stretch like this only. So when no stretch that means the same values are there in that means between 60 to 158 instead of 0 to 255. Now here the values has been stretched and they are now between 0 to 255 and once you are using a full dynamic range your contrast is definitely going to improve.

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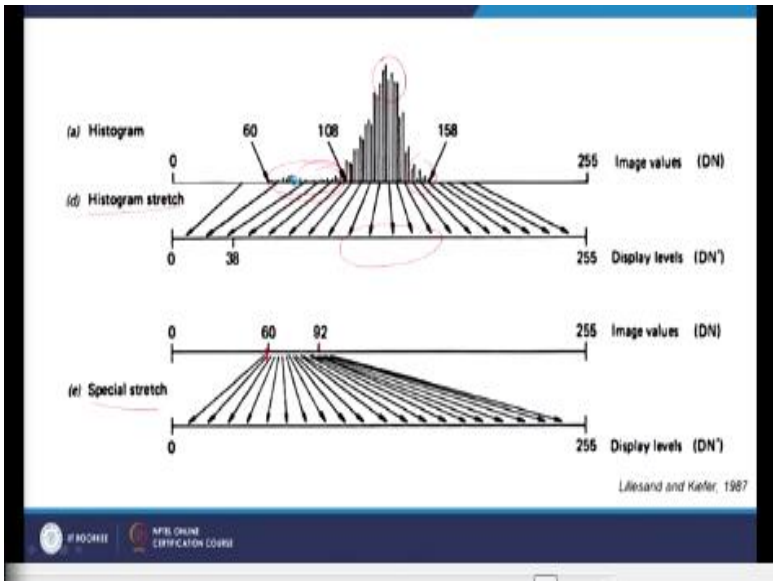


Now if there is another example rather than going for a linear stretch one can go for a nonlinear stretch, this is that example. So this stretch histogram stretch is like this, so where you had the more frequencies that part is stretch more. That means more distribution was created and where you had the less frequency, less number of pixels having those pixel values, they have been stretch less.

And likewise you can also do this histogram stretch or also called histogram equalization. I will repeat this is very important where you are having more frequencies, more number of pixels are belonging to a certain range of pixels you are distributing them more. And where less number of pixels are having almost same values the range of values you are distributing less.

So less values, less frequency values are less, more frequency values are more distributed. And this way it is basically equalizing the histogram. Because by redistributing these pixel value, so it is also called histogram stretch or histogram equalization which is more popular term used in digital image processing softwares or literature. Second is nonlinear also this first one is also linear nonlinear example.

A special stretch you choose that I want to stretch only the values between **0** 60 to 92 only, I am not interested in the higher frequency pixel value, I am interested in the lower part of my

histogram or first part of my histogram and stretch like this. That is a special kind of a stretch and that can also be done, it depends on my application.

I might be interested in water pixels which are representing the water body rather than land part. Because I am working on a lay or might be in coastal area and so on, so selective stretch can also be perform. So 2 basic types linear stretch which is shown in the previous example and like this one and nonlinear stretch 2 example histogram equalization and special stretch are possible.

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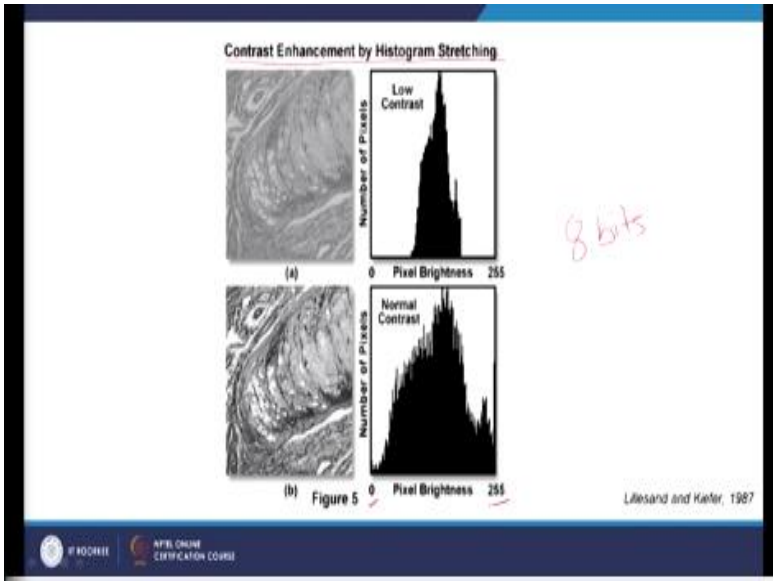


Few more examples are here, a input image as you can see left side and in histogram of input image low contrast as you can see. The distribution of pixels are not occupying the full range available that is 0 to 255, this is again 8 bit scenario. This is 8 bit scenario example is here but in the lower part when image is stretch this distribution has taken place. And now this is between 0 to 255 and you start seeing a contrast in the image.

Very simple way of improving image quality, either doing a simple linear stretch or contrast stretch, contrast enhancement by histogram stretching, that means histogram stretching.

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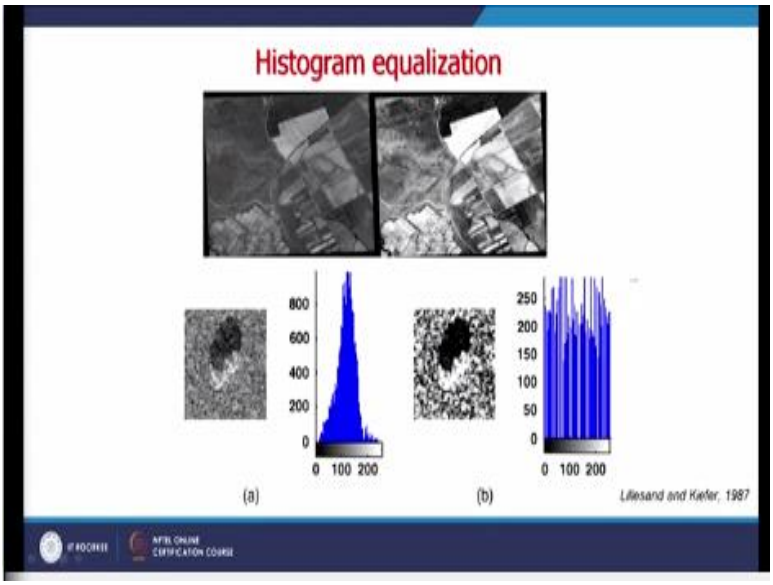


That basically a linear histogram equalization here as you can see that now the peaks there are many peaks earlier in the raw image raw image histogram. There were only few peaks are there, so the frequency is been distributed in the full dynamic range. And that the result would be much better in some cases. Each image enhancement technique cannot be true or fitting for all the images.

So for one histogram equalization maybe good for one particular image but it is not good all the time. So this brings to end of our discussion on simple contrast stretching either linear or nonlinear. By doing this thing we immediately improve this can be done very quickly using standard softwares or some photo editing softwares as well. And by which we can improve the image quality immediately. So this brings to end of this discussion, thank you very much.