INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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NPTEL ONLINE CERTIFICATION COURES

Digital Image Processing of Remote Sensing Data

Lecture – 09
Image Enhancement Techniques - 1

Dr. Arun K. Saraf
Department of Earth Sciences
Indian Institute of Technology Roorkee

Hello everyone and welcome to 9th lecture of digital images processing of remote sensing data course and I have divided image announcement techniques in two major sections and first one we will discuss in this lecture in the techniques 2 we will be discussing in the next lecture in this one we will first start with how very quickly how images accusation or data accusation from remote sensing satellite is done and then we will proceed with the first very simple processing techniques and so once the data is acquired that accusation then image processing starts.

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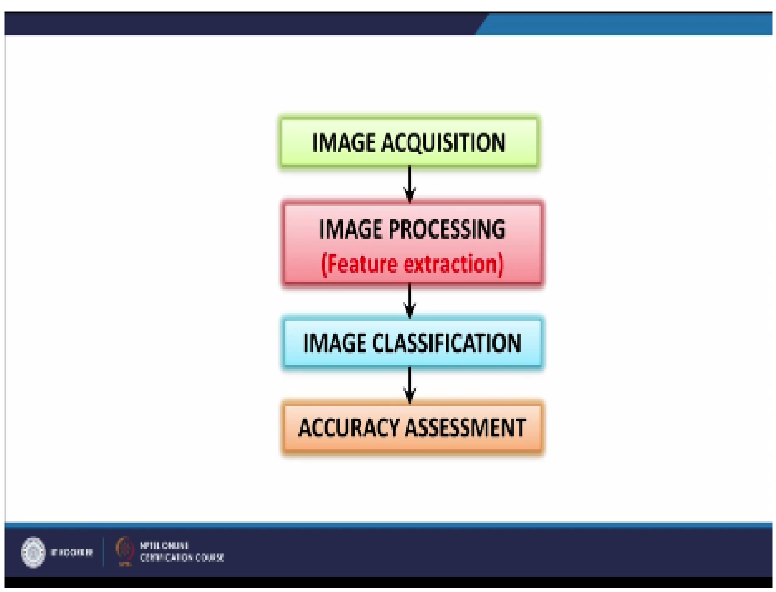

And untimely many be two further extraction that is through classification of different techniques and then image classification and finally we go for after classification we may go for the accuracy assessment to check how our classification got how we accurate it with the real thing did accusation you require satellite earth station which is on the ground on the surface of the earth rotating antenna or trucking antenna, this is the example of NOAA- AVHRR at satellite station.

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At IIT roorkee at department of our science and since October 2002 we have been running this earth station, so this is the external component of the earth station which one is seeing there are two in is antenna another antenna is GPS antenna which is a tinny one which one can see here very clear and the purpose here to keep track of timings and the location of the earth station so that because it is based on the production of the and satellite orbits and therefore these two things are required very accurately for the accurate data accusation.

And the second component that is the internal component of earth station is inside which is simple a pc based depending on type of satellite the data.

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But now a days it has become so simple that you can have a simple desktop computer and receiver which is also shown in a large form and there is a software which controls everything so using such a set up data is acquired for other satellites the set up might be little different but influence will it will have two components one is external antenna and tracking antenna and the second component a computer and a receiver so which receives an computer and record the data one the hard disk for further processing.

Each satellite will have it is own foot print and this is the foot printer of on heavy HRR relative to our earth station ITTR satellite earth station which in sort ITTR's which is located here.

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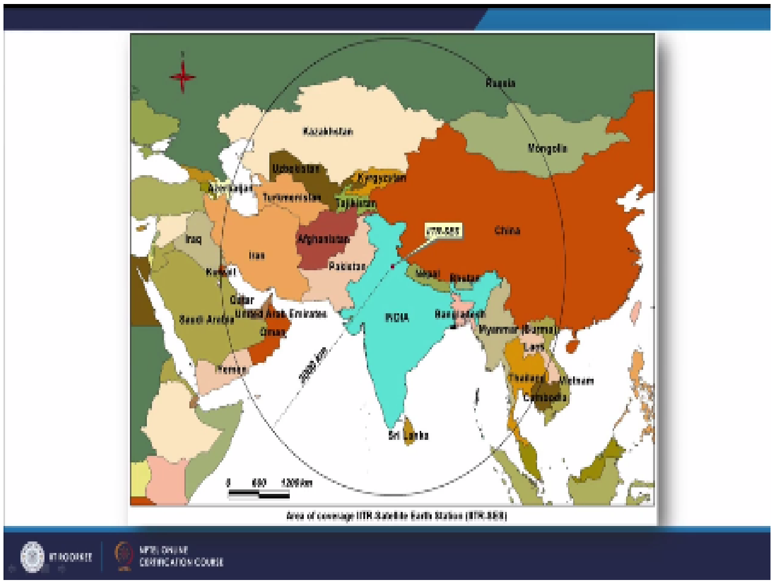

And say inverted corn base of inverted corn plotted on the map of the south East Asia and which covers it very large area so 3000 km radios circle that means any where if satellite is over passing like from here to here or may be north bound satellite may be passing over orbiting from to here the data can still be acquired it is not necessary that the sort over pass over IITR's in for all solar orbiting or polar orbiting satellites such requirements are there and I am not taking about geo stationary satellites are some different types of orbits many of these near polar orbit satellites or also we call sun sun corner satellite.

So set up is like this depending on the resolution if it is having relatively courser resolution then it will cover a very large part of the earth like in this case entire Himalaya which is about 3000 km and roughly in that length which you can see here.

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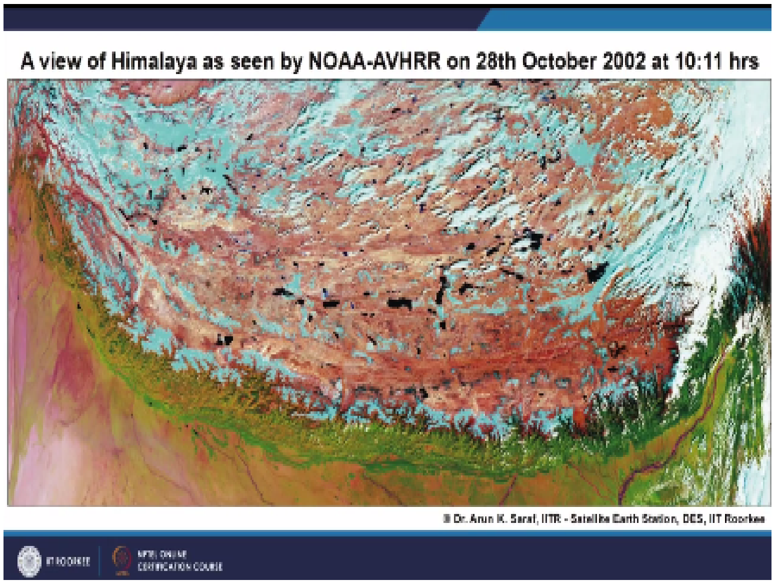

Is in just one see without any massacre or anything you are seeing the either Himalaya here so because it is having a special resolution of 1.1 km once the resolution improves instead of having suppose 1.1 km if it would have a resolution or say 500 m then the my swath or the width of my seen will reduce may be roughly half, so it depths basically on the special swath is completely depending on the special resolution higher the special resolution smaller width of the swath more closer the special resolution like in case of NOAA- AVHRR.

Swath is very big and a large area and at counted internet scale can be covered this is the example because NOAA- AVHRR is also having thermal channels so using visible channels.

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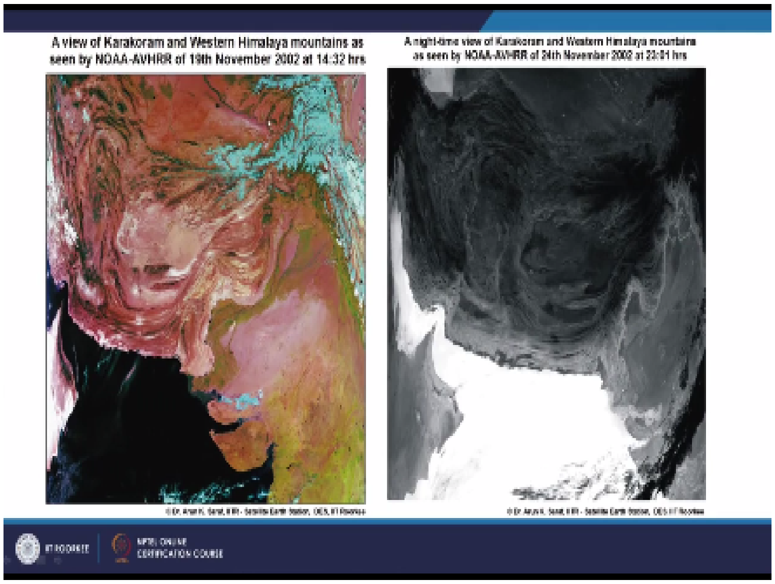

This is the falls colour composite of a western India and parts of Pakistan Afghanistan and Iran and some countries of form soma Intiman are also show here this almost the same part of the same area is been acquired in the night time of thermal channels it looks something like x ray but these are very useful thermal channels and because these can be acquired in night time the data in thermal channel can also be acquired because you do not require the solar energy for data accusation.

Now for the image enhancement as we have seen that discuss that digital image is a two dimensional matrix and if you are having multi spectral data like in this example and 4 bends are soon here.

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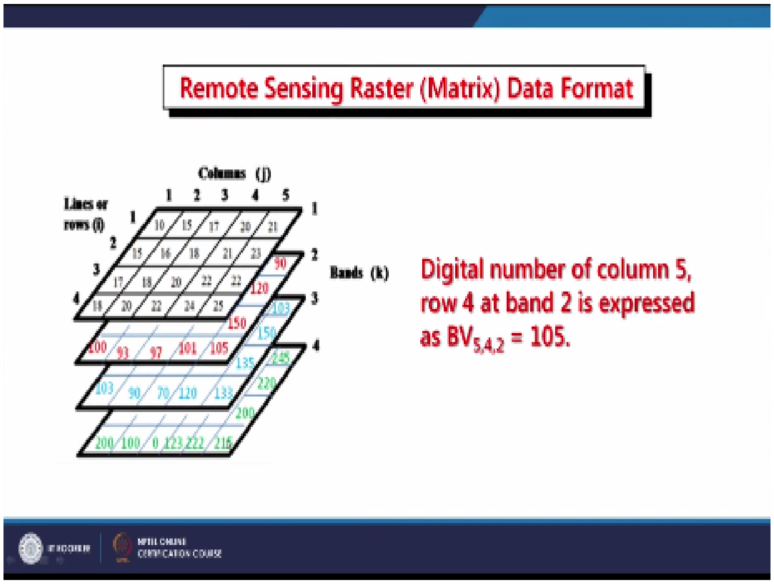

That means say they will stuck together and data will be acquired in case of NOAA- AVHRR example at a time or almost every time when ever the data is acquired the data was acquired in five channels so but in night time because you do not have the visible channels so only far infrared ad thermal infrared channels 3 channels data is required otherwise in day time 5 channel data is acquired of the same area.

And this is exactly shown here for different band you can see line or like this which we address columns are from top to bottom and this is how the data of remote sensing remains in the system.

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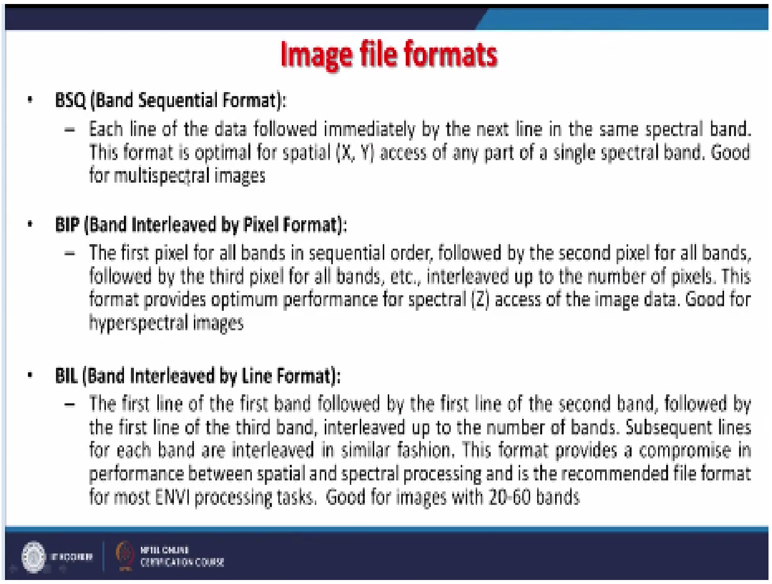

Now once the data is acquired by a satellite earth station there are various ways of storing the data and the first is called BSQ or B band sequential format which in which the each line of the data followed immediately by the next line in the same spectral band that means the band the data will be stored band y band that means if we are having say 4 bands then first band will be stored the 2nd band 3rd band and 4th band I will be discussing two more major types of and digital data formats and then we will be see what is the advantage with each and dis advantage also.

Second one is the BIP which is the band interlinked by pixel format that the first pixel all bands in sequential order followed by the second pixel of all bands and likewise the entire images stored so again if you are having 4 channel data or 4 bands data then the first pixel of first band is stored first pixel of second band first pixel of third band and first pixel of fourth band then second pixel of first band second pixel of second band second pixel of third band and second pixel.

Likewise the data is sorted and this is 3rd one is the bill format which is band interlinked by line format where for each band a line is sorted so likewise that the first line of first band is stored then first line of second band first lien of third band and so on and so forth now when we see the advantage is associated with the different kind of these formats like for example with band sequence and format that is BSQ good for multi spectral data.

Because all the bands are one after another and the BIP is good for hyper spectral images which is now we are talking about 256 images earned more many more images so because when we want to retire the data then we do not have to go at the end of the entire data set so this allows us to retire the data only for that part of different so if number of bands are there in a sensor then BIP is much more compared to other to image formats like BSQ and BIL format and Band interlead by line format good for the images of moderate number of bands 20 to 60 rather than 256 in case high per spectral, so a many image processing popular image processing software have also evolved their own image processing or image formats and there are some other image formats are also will available.

So when we will discuss about the and data compression techniques and dead time we will also discuss some popular image formats which are used in digital image processing and this is a further elaboration on this that the in the your BSQ this is how band1, band2, band3.

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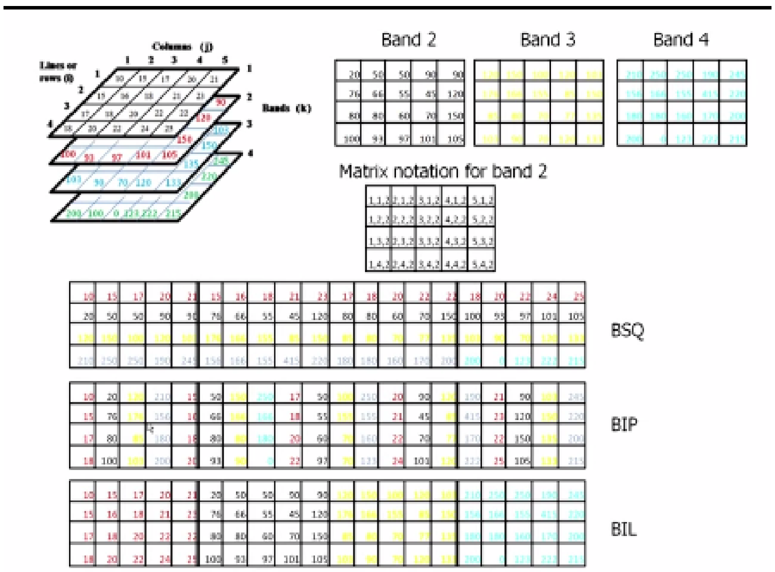

All are is to and likewise you are having a BIL format then in BSQ format it is something like that and in the BIP format one after another.

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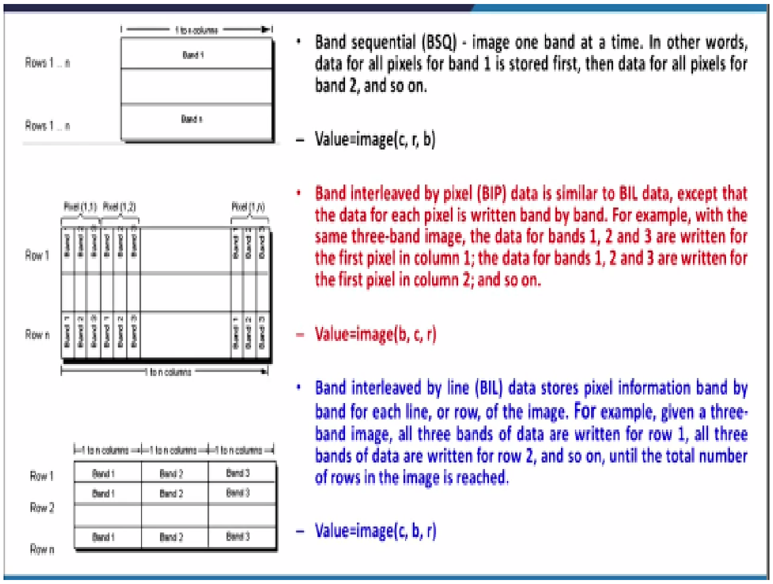

And Band sequential bases image and band at the time in other words data of all pixels for band 1 is stored first then data for all pixels of band 2 and so on and so forth, so when in the BIP the data is similar to BIL except the data for each pixel is returned band by band and likewise these different systems or different image formats have evolved is for the requirements and also changing with the time also.

Now the next important thing once the data has been acquired by the satellite no matter in which format basic image format you have stored, next thing comes how to improve the quality of image, why a quality of image is required as I told in the beginning that is in the introduction video and that once the data is acquired because the data is being acquired from about 840 km because the satellites are orbiting that depth in a space.

And in-between we are having the atmosphere, atmosphere also deteriorate the quality of image, as well as the there are some other distortion like geometric distortions can also come, some distortion might will come may come through the problems with the sensors and once the data on the earth through these data acquisition systems earth stations then we process the data and try to improve the quality of the data as well as bring the geographic coordinates.

So they can be used on with other data sets especially on GIS platform, so there are many remote sensing data sets which contain high quality accurate data.

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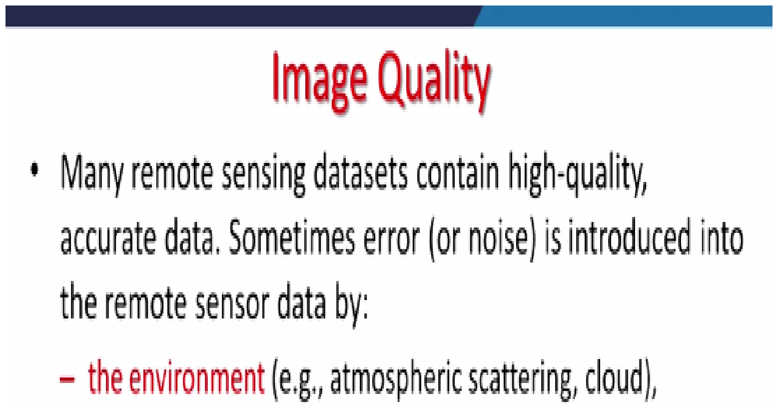

Sometimes error or noise is introduced into the remote sensing data noise may be from because of wrong calibrations of sensors or noise may be because of some other factors, now the data may have the problem because of atmosphere which is present within the, and between the satellite and earth and may be scattering atmospheric, scattering absorptions and clouds may be in between and to some extent clouds can also be removed.

But they are always trade of while removing the clouds that is the different discussion we will npt go in detail then there might be distortions or problems or malfunctioning which may be the random or may be systematic of remote sensing systems and due to the hardware problems un-calibrate detects or sensors which are on board of the satellites and they may be improper preprocessing was the data is acquired.

Then initially some pre-processing is also done on the data so there if inaccurate this analog to digital conversion is there then it may bring the ultimately the poor quality of the data, as we have discussed in case when we have discuss the advantages of studying histogram. So the first the step in image processing is to check the image statistics and that can be done very easily by looking histogram of individual bands.

So if I am working home 5 or 8 bands then I should first study histogram of each bands and depending on the shape of the histogram how pixel values are distributed I would then proceed for different image processing techniques and these things I have already discuss.

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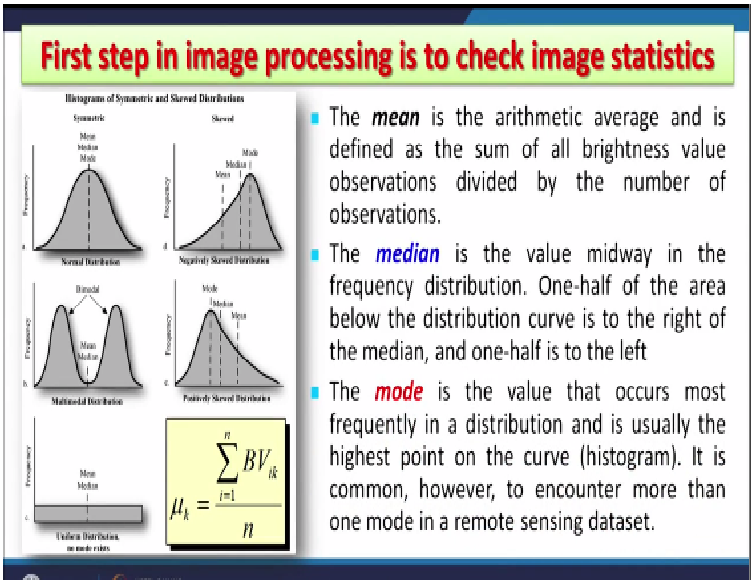

In case of a when we have discuss the advantages or why to use histograms and in that discussion we have involved that it is very weird to get normal distribution in the satellite data sometime we get negatively skew distribution because of may be some land features may be having high pixel values may be like in desert area or may be a snow covered area in hilly region you may have a bi-model distribution this may be in a region like in coastal areas or where a border a large border OD is there and land part is there both will have different properties or different values pixel values and therefore there will be they will be distributed completely differently, you may have a positively skewed distribution just above it to the negative one.

Again uniform distribution is rare only in case if you are if you have acquired the data of a completely snow covered area and that too is a flat area or a completely desert land and there no land features are there no vegetation no water bodies are there and therefore you might get more or less something like this histogram, anyway so the, also one has to look the statistics and note much complicated one very simple features has been has to go through like mean, median and mode.

How things are distributed and this will help us to choose appropriate and digital image processing, technique to enhance our images for better interpretation, generally image processing techniques can be divided in two parts or two sections one we call preprocessing and then second is the post processing, so in preprocessing.

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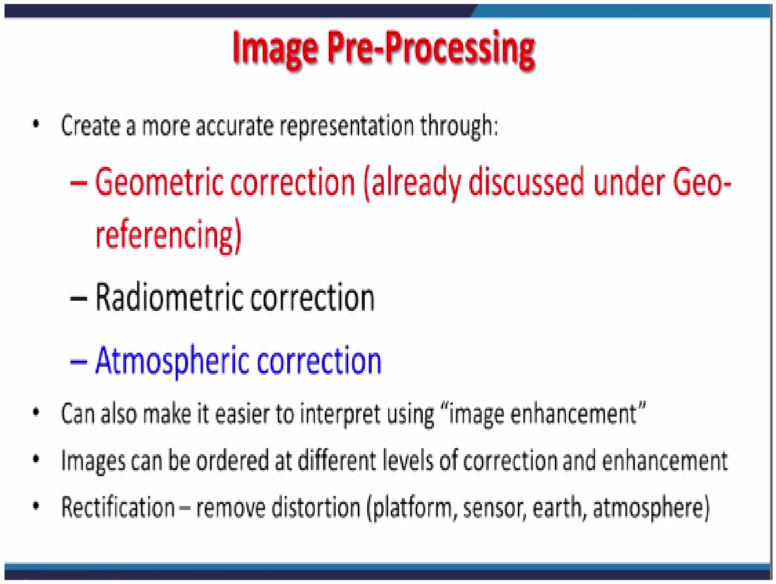

Create a more accurate representation through geometric corrections, geo-referencing techniques which we have discuss in the previous lecture as a is already there we have we know that why the distortions are coming and how to correct them to a large extent and in case whether the data belongs to a high resolution or low resolution is still geometric corrections can be performed.

And the only the requirement in case of very high resolution high spatial resolution remote sensing data is that our quality of GCP's has to be very high but otherwise all types of remote sensing data acquired by polar orbiting these sensing coolants satellites can be corrected using geo referencing techniques which we have already discuss. Radiometric corrections can also be preformed.

But you require the individual like if it is a linear array or sensor then you require the well use of individual cells how CCD's how they are performing generally radiometric corrections are done by those who acquire the data and supply the data or upload on the internet. So radiometric corrections generally is not done at the end user label, atmospheric corrections of course atmospheric correction may be performed by an inducer.

For to improve the quality of image to some extent the distortions which are coming because of the presents of atmosphere can be removed easily there are some sort of brood fords enhancement techniques which are very simple and you can remove but if you there are some models are available by implying those model one can remove the atmospheric and distortions and also in order to remove atmospheric distortions.

You require lot of data of the same time when the data was acquired, and therefore this removing atmospheric distortions is time consuming but if it is required for some quantitative analysis or remote sensing data in various application which is very much required then atmospheric corrections can be performed. And also can it make easier to interpret images using image enhancement technique which we will be discussing now.

An image can be ordered at different labels of corrections in enhancement, we can also those who supply the data we can ask them for a different levels of corrections in enhancement they can supply absolutely readymade data which will have completely good enhancement all kinds of distortions are removed in geo reference data just we start and using them for interpretation, rectification say that is geo-referencing we have already discussed.

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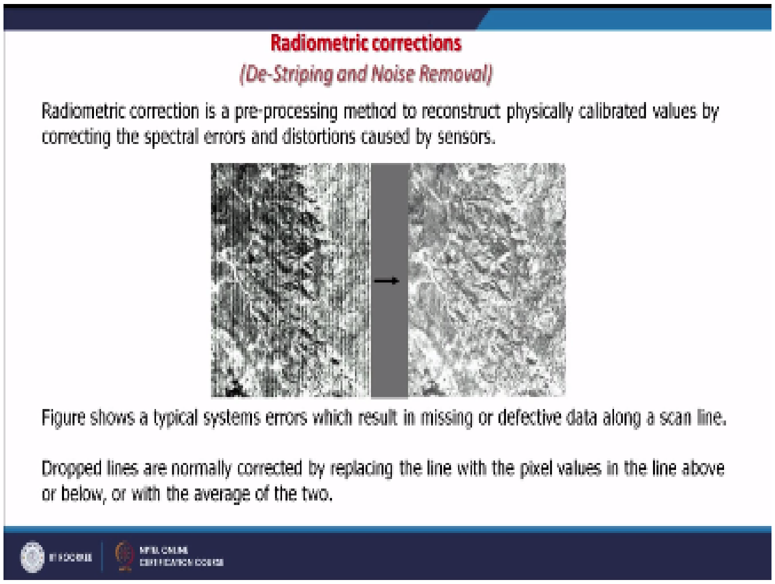

So let us go for radiometric corrections and there might some simple one may be systematic bond de stripping and noise removal and so radiometric correction these may come because of the performance of different sensors on board or CCD's on a linear scanner, so radiometric correction is a pre-processing method to reconstruct physically calibrated values by correcting the spectra errors and distortions caused by the sensor.

This so in order to correct as I have already mentioned few seconds before that in order to make radiometric corrections you require the values to which only those who have developed the sensors, tested or calibrate with the sensor they can apply. But the example here is shown about the de-stripping and noise how it can be removed and here if it is systematic errors or systematic noise which can be removed much easier but if it is nonsystematic then it becomes very difficult because pixel is difficult to correct but if there is a systematic error then appropriate argonian scan be developed they are already some and these can be employed to remove like in this example.

So this is a system errors which results in a missing or defective data along a scan line and that has been removed. Dropped lines are normally corrected by replacing the line with the pixel values in the above and below and averaging the two, because once you have lost the original data then there are no ways to recover that data. So how one would recover from neighboring pixels and this is what it is done in this to remove this stripping affect from what bringing this de-stripping technique this is how it employs.

It takes the values from adjacent pixels average them and put to the for an in corrupted pixel. You might be having this type of error that is the speckle noise kind of error generally occurs in the microwave data but still if even in optical data if it is there it can be removed there are different techniques are available in this example here.

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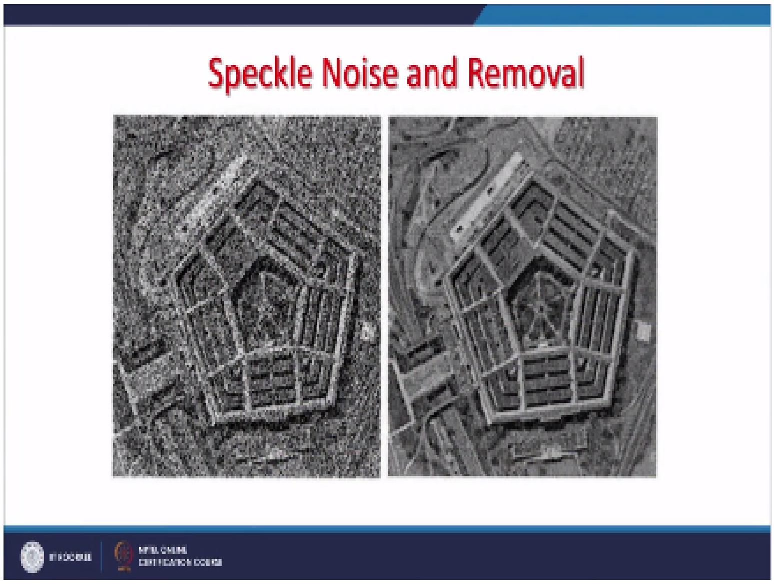

That a speckles has been completely removed from the data and now this processed image looks much better and then interpretations can be bare highly reliable if we make the interpretation on image which is suffering from noise then there will be problem now, atmospheric corrections because we know that.

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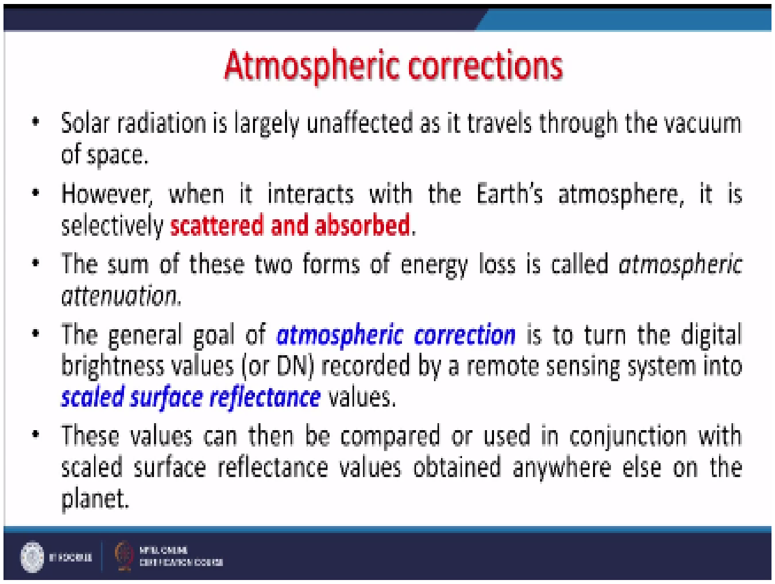

Solar radiation is largely unaffected as it travels through vacuum of the space. However, when it interacts with the earth atmosphere it is selectively scattered and absorbed. Why selectively because in different parts of EM spectrum this performance or behavior is different and therefore this word selectively has been used and both kind of these phenomena below scattering and absorptions.

An ultimately these phenomena brings the poor quality in the image about remote sensing image, so it one always try to remove as much as possible or minimize their effects in the images over image quality improves for better interpretation. Sometimes some of these two forms of energy loss we call that atmospheric attenuation. The aim or goal here is about atmospheric correction is to turn digital brightness value that is pixel value recorded by a remote sensing system into the scaled surface and reflectance value.

It depends on which part of EM spectrum or in which band you are working, and these values can then be compared to use in conjunction with scaled surface reflection values obtained anywhere else on the planet, and this is how these models have developed to remove the atmospheric correction, so the basis of these models are like this and because as I have mentioned that scattering absorption refraction and reflection.

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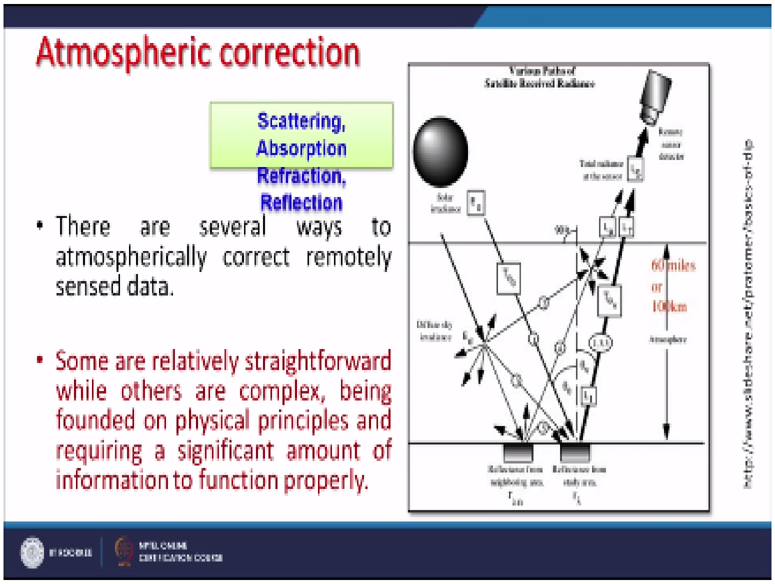

All these phenomena are there and this is the sun is there this is satellite is shown and all these are occurring within this atmosphere within that 100 kilometer, and that creates a lot of problems in our satellite images these are several ways to atmospherically correct remote sensing data. Some are relatively straight forward as I have told earlier we put them as a group force kind of things some are very complex one being founded on physical principles and requiring a significant amount of information to function probably.

What did that information is the weather data at the time when data was acquired by the satellite, the corresponding weather data is very much required in order to achieve a very good atmospheric correction so that it depending on your required one would collect the data and do that kind of correction. This I am showing just one example.

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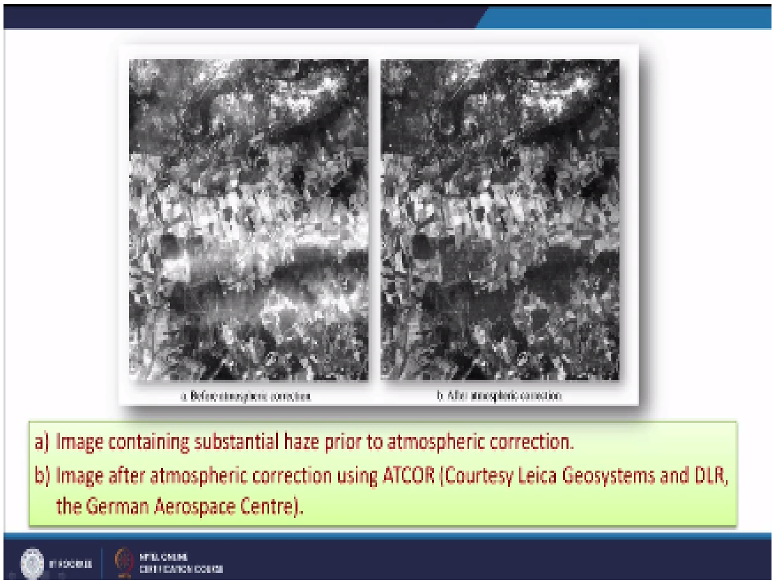

This is the image before atmospheric correction and this is the image the same image after atmospheric correction, so the distortions which we are coming on the left image where due to the hays and this is a very common phenomena over large cities like in Delhi or over bridging generally we see there is hays and even on the ground we can see, so think that when the satellite is acquiring the data it will, it has to completely map or incorporate this hays in its data.

Now this ways the presents of hays will reduce the quality of image and once major suffering from that then interpretation based on these images may be also having a poor quality. So in order to remove this then atmospheric corrections can be performed like here and on the right image that hays has been removed and this after atmospheric correction using the example here is this at core model this is there but there are many various models have level depending of location and the availability of the metrological data one can go for different kind of models.

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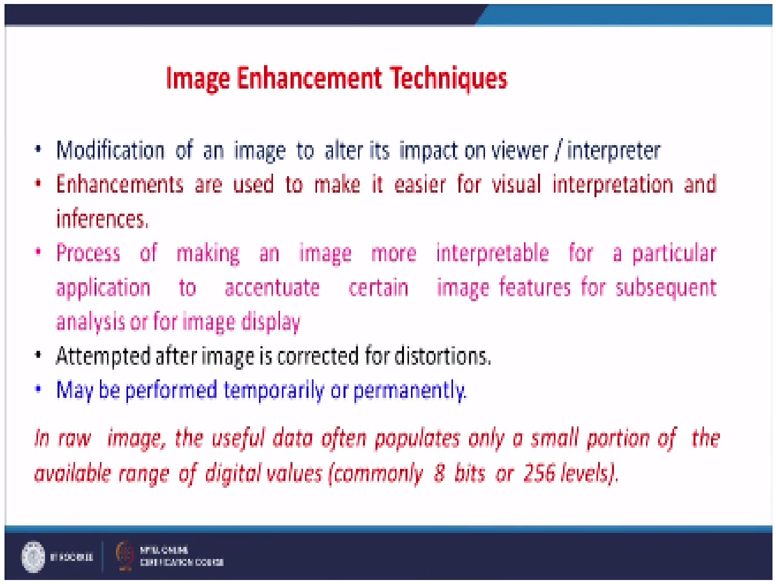

Image enhancement techniques modification of an image this is the definition which we are going through that modification of an image is to alter its impact on viewer or interpreter. Ultimately, we are going to use image to interpret go for classifications use the image because this is the main purpose of acquiring the remote sensing data.

So enhancement are used to make it easier for visual interpretation and inferences, inferences is very important thing in the roughly at the end of this course I will be showing some examples where just making interpretations and making inferences how one can use these remote sensing data for different applications may be for ground water, may be for earthquakes your studies maybe for fog studies and so on and so forth.

So process of making an image more interpretable for a particular application to accentuate certain image features for subsequent analysis for image display that is the main purpose of image enhancement, and this is attempted after image is corrected for distortions, first atmospheric distortions are removed geometric distortions are removed geo-referencing is performed then we go for image enhancement and may be perform temporarily or permanently.

Generally we go for temporarily because we keep original image in depth and a new image is saved which is not having all these distortions and having these image enhancement and better quality for image interpretation, so raw image is useful that is data often populates only small portion of available range of digital values. So when you display histogram of a raw image you would find generally that it is occupying on axis scale how point only a small range.

And whereas our digital image processing are capable of displaying data if I am giving example say of 8 bits then 0 to 255 so that, so we can rescale by implying this image enhancement techniques. There are different types of image enhancement techniques one is based radiometric enhancement techniques that is modification of brightness value of each pixel and image data set independently point operations.

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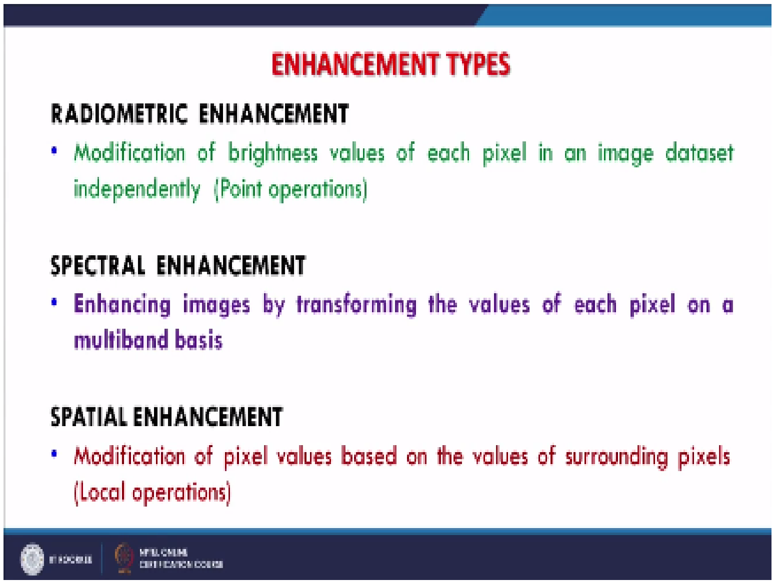

Generally this kind of thing is not done very rare to do spectral enhancement is more common which is enhancing images by transforming the values of each pixel on a multiband basis, because not only we will be working on one single band but multi band using multi spectral data and spatial enhancement modification of pixel values based on values of surrounding pixels that is local operations.

In case of missing with pixel values or some operations like spatial filtering other things the use the values which are surrounding a target pixel and then modify the

Some operations like the special filtering other things we use the values which are surrounding a target fiction and then modify the pixel vale of the target pixel, so radiometric enhancement if we discuss that is the.

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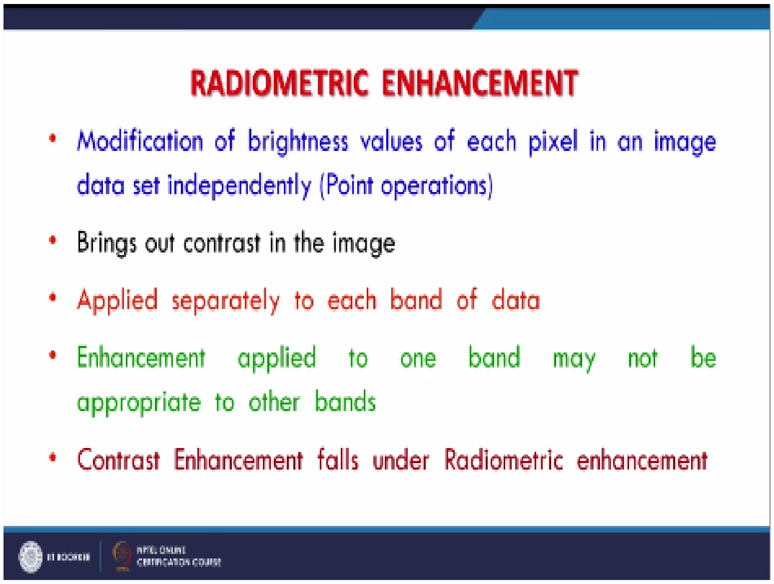

Modification of brightness values of each pixel in an image data set independently and brings out contrast the image ultimately the equality of the image it looks better for interpretation applied separately to each band of data and enhancement applied to one band may not be appropriate to other bands this is one has to remember in case of one is doing an image processing for multi spectral data then this technique should be performed one individual, the geometric corrections and another things is fine.

But these techniques will be performed on this contrast a contrast enhancement basically falls in that the radiometric enhancement.

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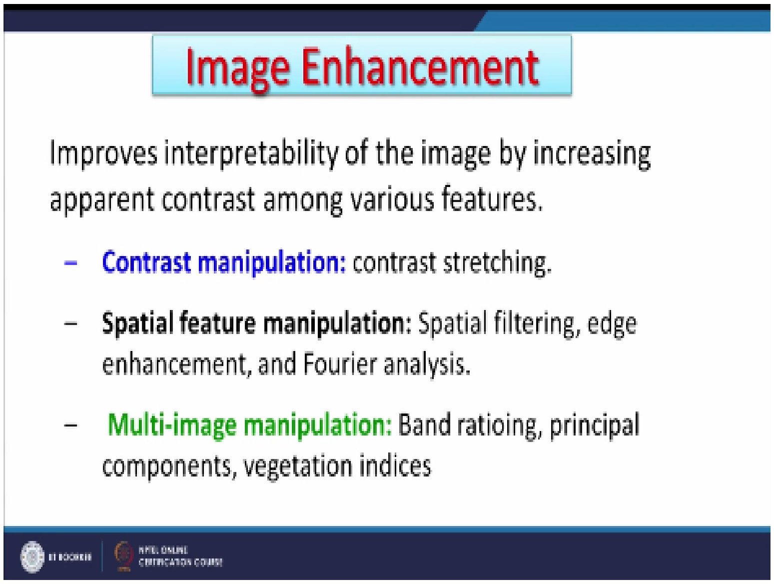

So in an enhancement improves interpretability of image by increasing apparent contrast among various features, contrast manipulations which is be put them as contrasts stretching, contrast enhancement is special feature only manipulations which is a special filtering edge enhancement and Fourier analysis which is not in the special domain, but in frequency domain but you know do the inverse transformation, so we put them in a this category there is special feature manipulation.

And third one is the multiple image manipulations and that instead of using one brand we use multiple bands, so may be your technique like band rationing which is arithmetic based principle components more statistical base and then vegetation in this basis again arithmetic there are various in this is have been developed and pass depending on the data available number of bands and so on so for there the why images suffers from low contrasts is I have been discussing because the.

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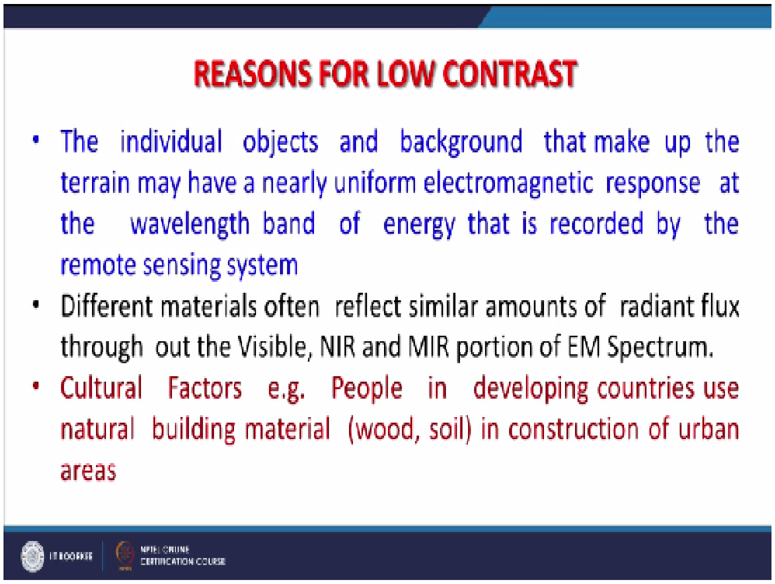

Individual objects and background that make up the terrain may have a nearly uniform electromagnetic response, at the wavelength band of energy that is record by remote sensing system, so this say if a the land part which is being scan by a sensor having a homogametic present mat be a completely for as cover area or a desert area or a snow covered area then we may have lack of contrast and that lack contrast may create problems during a interpretation but if within one image lot of different.

Materials are present a different land features are present they will have different reflectance or other values and therefore they will have a and may have better appearance, so different materials of reflect similar amounts of radiant flux throughout the visible near in our mid infrared portions of EM spectrum cultural factors for example people in developing countries natural building materials good soil in construction of urban areas and these may also bring low contrast in Em, further sensitivity of detectors if detects transmit the electron part of sensors is not good.

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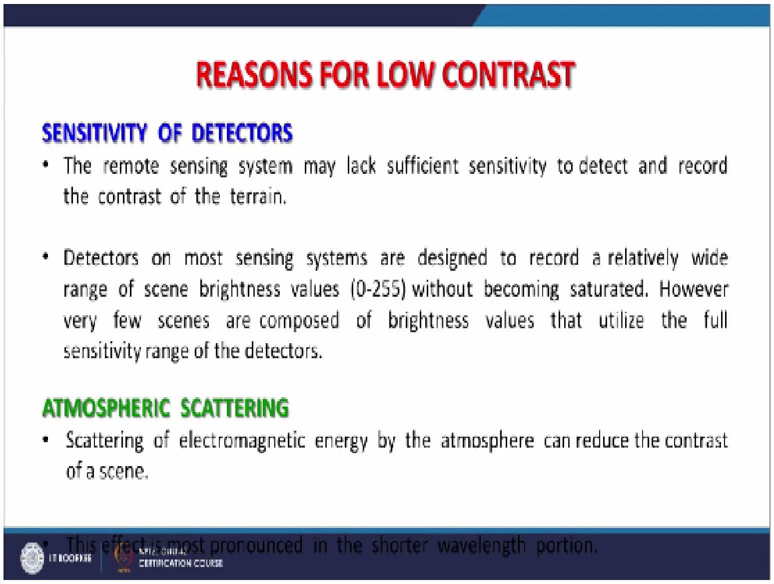

Then that may also be the reason for local trans that is remote sensing system may lack sufficient sensitivity to detect and record the contrast of the terrain, these problems where earlier when we started this similar remote sensing in 1970, but now things have really improved in the image quality a special resolution radiometric resolution all the resolution are improving so detectors on most sensing systems are designed to record a relatively wide range of scene brightness values 8 bits 0 255 without becoming saturated, but in some cases very few scenes are composed of brightness value.

That utilizes the full sensitivity of or range of detector and if a an images having this kind of occupancy of pixel values completely, exhausting then there is no scope or any further enhancement atmospheric scattering may bring the low contrast that is scattering of electromagnetic energy by atmosphere can reduce the contrast of a scene and this affect is most pronounced on shorter wavelength, so the bands like weight band went to in case of land said Ms as or land at etmt and well I these throughout problems may come.

Now we come for this contrast enhancement the first one that among the difference between average.

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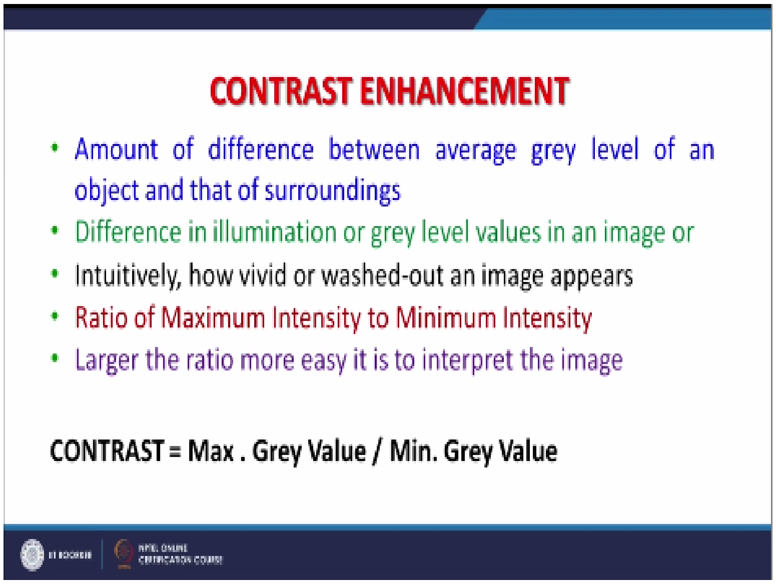

Grey level of an object and that of surroundings, so we put that as a a contrast enhancement the difference in illumination or grey level values of an image or intuitively how vivid or washed out and image appears ratio of maximum intensity to minimum intensity, larger the ratio more easy is to interpret the image so contrast enhancement basically maximum grey value divided by min.grey value.

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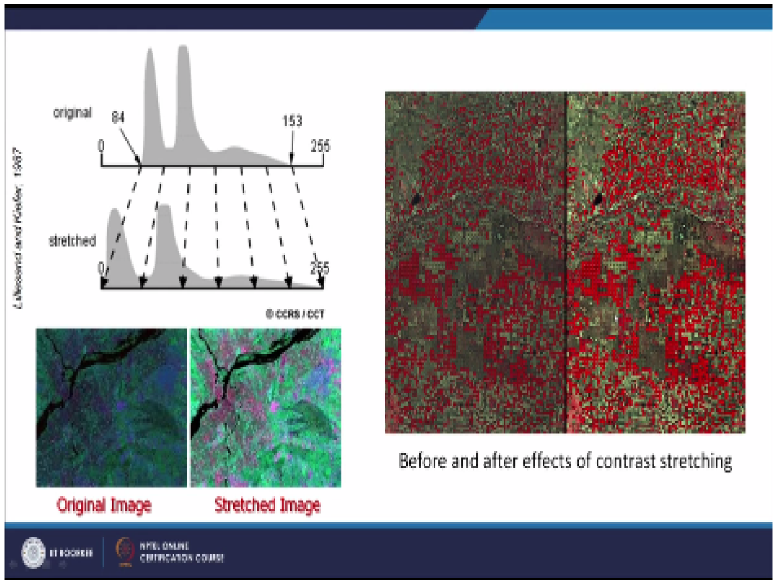

This is the example here what we are saying that on the left side you are having original image on the right side you are having stretched image or enhanced image, so the original image had this kind of a by model and distribution in the histogram the same histogram has been stretched to the full length which is available for us between 25 and 0 255 and once be do it and we reached a this kind of image which is much better for image enhancement and which is much better for image interpretation.

Similarly before and after effects of this contrast stretching are shown here, and the interpretation may be very difficult but once the image has been in the contrast of the image has been improved by implying a simple image and enhancement technique then our interpretation will definitely improved.

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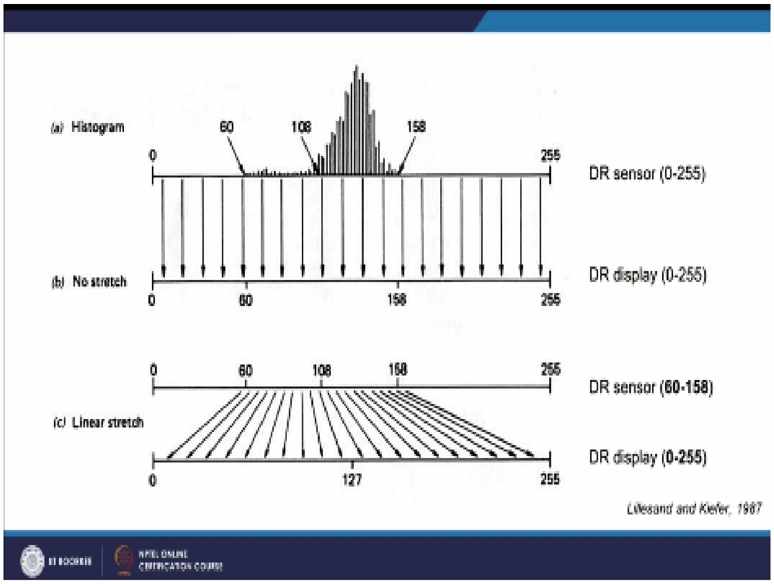

There are some other ways of a and doing this thing again the back example is the histogram where the values are being distributed between 60 to 158 where as the range available in digital image processing in a 8 bit based is between 0 to 255, so we can rescale this thing and though then these values can be stretched that is why it is called a liner stretch of contrast stretch because we are redistributing values from between in this example between 62 and 58, 0 to 255 and in by bringing this the stretch into the distribution of images ultimately.

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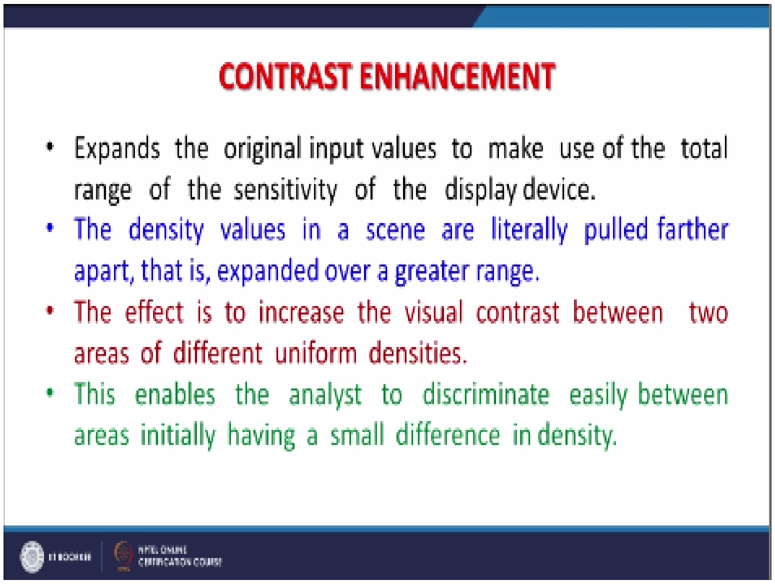

Ultimately we improve the image and contrast and better interpretation so contrast enhancements expands the original input value, to make use of total range of the sensitivity of display with devices and that the density value, values in a scene are a literally pulled farther apart and that is expanded over greater range that is why I am using wanted stretching, and the effect is to increase the visual contrast between two areas of different uniform density and this enables the analyst to discriminate easily between areas initially having a small difference in the density.

So the values difference between two edges and areas or two edges and pixels becomes larger and therefore the contrasting proves, there are different types of contrast enhancement which pixel values in most scenes occupy a small range of values.

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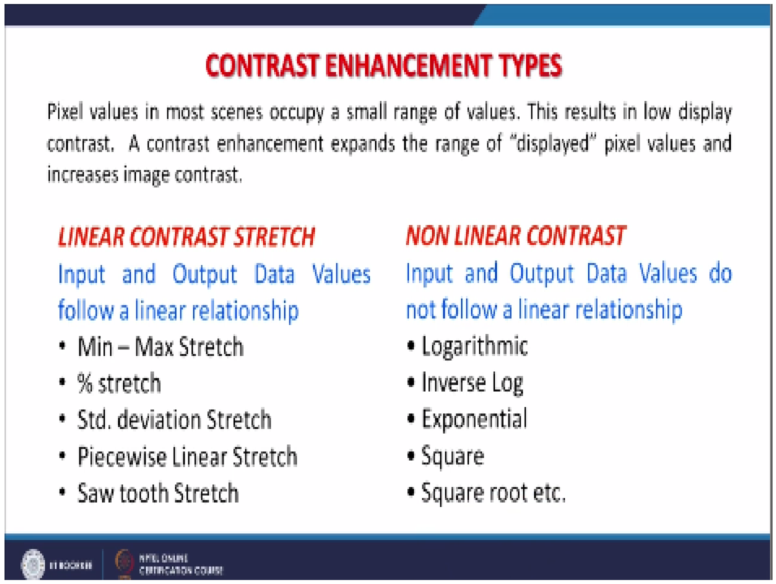

Draw a images generally we will have if you see the histogram they will occupy very small part to be in part which is available in between 0 to 255 and this results to load display contrast a contrast enhancements as mentioned expands the range of displayed pixel values, not the original one but the displayed pixel values through LUT which we have discussed in previous lectures and in increase the image contrast so there are various types of image contrast the linear contrasts stretch.

That the input and output values follow a linear relationship and minimum to maximum min and max stretch we also having percentage standard duration stretch piecewise linear stretch and a to tooth stretch, various types of algorithm and various approaches people have developed and but these are which will fall on this linear contrast and once you are having linear then definitely and there are non linear contrast enhancement techniques where input and output data values to not follow the liner relationship.

In case of linear they follow the linear relationship and non linear contrast like logarithmic, inverse log exponential square, square root etc.

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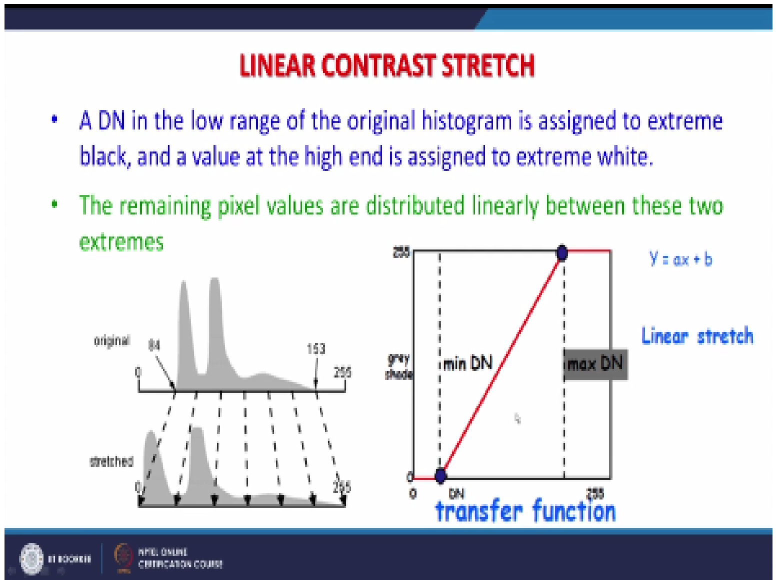

So first we will take the linear contrast stretch which are based on liner concept that a digital number of pixel value in low range of original histogram is assigned to the extreme black and the value at the high end assigned to the extreme white and the rest of the values are distributed in distributed in between and this is simple linear contrast stretch remaining pixel values are distributed linearly between these two extremes in example shown here, and this is how the look after table is the transfer functions.

That and the original values where here between say and with the 42 and 200 now this has been stretch between 0 to 255 and this is how the advantage of look up table and by which we can achieve linear contrast has very easily by spending the expanding the original input values of the image that total range of sensitivity of the display can be.

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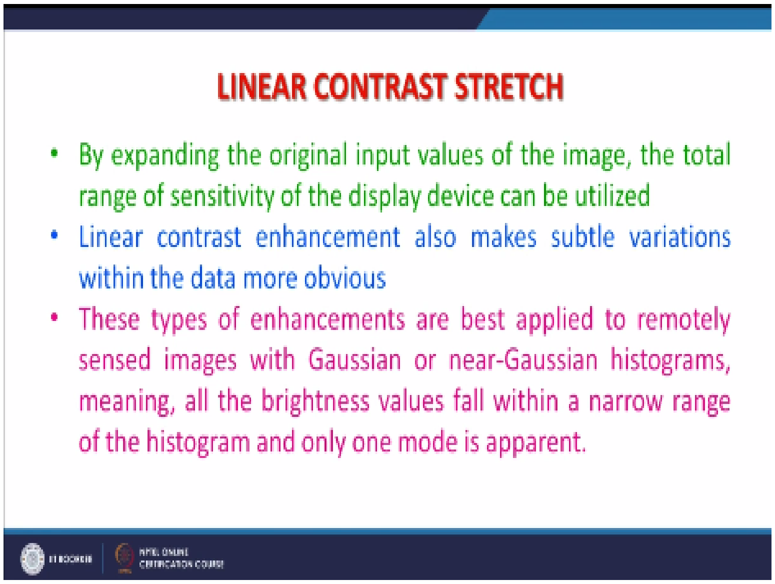

Utilized which is available between 255 and linear contrast enhancement also make certain variations within the data more over and these types of enhancements are best applied to remote sensing images with Gaussian or near Gaussian histograms that means a normal distribution so if you are having distribution which is near normal or normal then this is the best technique to implied which is there is simple one and very quickly one can achieve very good enhancements so this brings to end of a this particular lecture which is first part of image enhancement in the next part we would be seeing more linear and enhancement techniques and as well as non linear enhancement technique thank you very much.

For Further Details Contact
Coordinator, Educational Technology Cell
Indian Institute of Technology Roorkee
Roorkee – 247 667
E Mail: etcell,iitrke@gmail, etcell@iitr, ernet,in
Website: www.iitr.ac.in/ETC, www.nptel.ac.in

Pankaj Saini
Arun. S

Web Opreations
Dr.Nibedita Bisoyi
Neetesh Kumar
Jitender Kumar
Vivek Kumar

Production Team
Sarath. K

Camera
Mohan Raj

Online Editing
Jithin. K

Graphics
Binoy. V. P

NPTEL Coordinator
Prof. B.K. Gandhi

An Educational Technology Cell
IIT Roorkee Production