Mine Automation and Data Analytics

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Week-5

Lecture-25

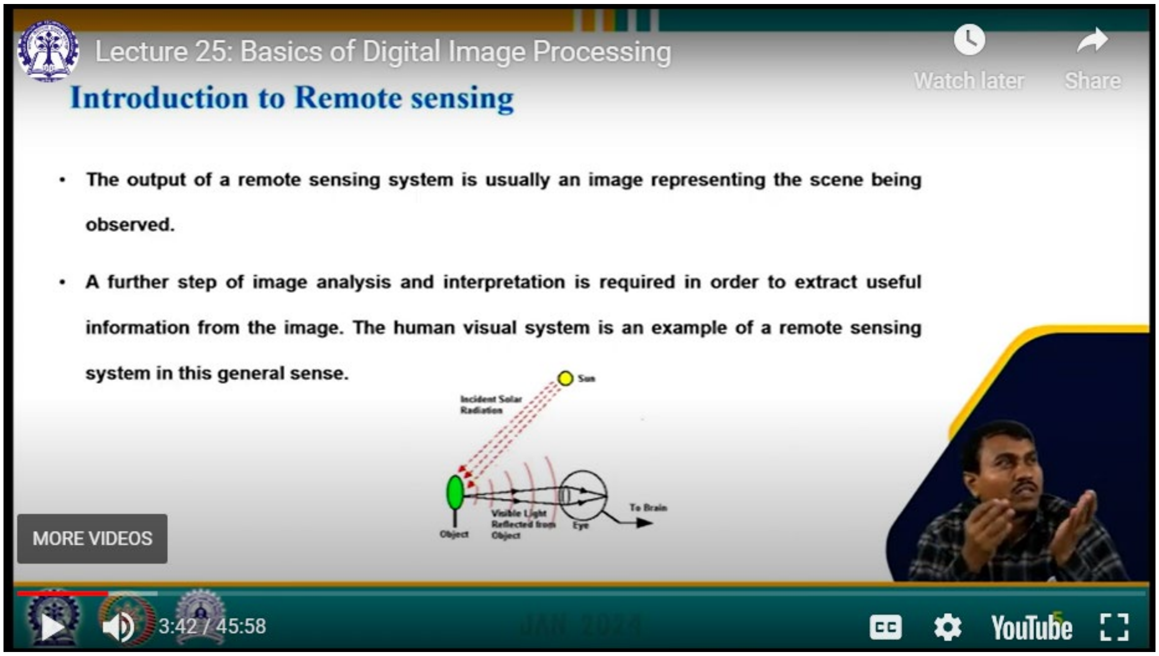
Basics of Digital Image Processing

Welcome back to my course, Mine Automation and Data Analytics. Today, in this lesson, we are going to discuss on the image processing, the image acquired by the remote sensing technology and throughout this course we have already discussed different applications of the remote sensing imagery in the mining automation. So this course will dealt with different techniques and the technology adopted in remote sensing imaging and the image processing for extracting useful information for different purposes.

So, in this lesson, we will cover the following. The introduction is about remote sensing, and then we will discuss the different techniques adopted and available in remote sensing and the imaging that is images are captured using the different EM spectrum, for example, optical infrared and microwave technologies. The processing of the images and the restoration of the images because different times we have observed there are certain disturbances so we need to restore and the image analysis.

So, remote sensing is basically a technology that refers to the activities that we are observing, we are perceiving, we are recording by some sensing mechanism about some phenomena or about some object from a far away place, from a distance place, and the sensors are not in direct contact with the object, and that is why that is why it is called remote sensing. So, this information because of non-contact method, this information is basically carried by a physical carrier or it travels through the physical medium, and here basically, the electromagnetic spectrum basically works as a carrier. So, the output of a remote sensing system is usually an image representing the scene observed or representing the object we are observing.

A further step of image analysis and interpretation is required in order to extract useful information from the image. So, the human visual system is basically more or less the same kind of things as you can see in this figure. So, as a human eye we basically perceive what is in surrounding in front of us. So, it is basically there are some light sources that is fall on the object and some amount of light is basically reflected to us towards us, and that amount of light is basically accepted by the human eye, our eye and we have a perception system in our brain that basically process the data and based on that I can see as it is a watch, it is a chair, it is a computer like that. So, this has been very well explained in this particular figure.



So, this is the light sources. So, the light sources fall on the object, the optical light I am talking about here. So, the visible spectrum of the light is reflected back to the human eye and human eye is a very good receptor and receiver. That amount of light absorbed and get and it is basically sent to the brain and we are basically working on that. Basically, by that we are perceiving, we are able to know the surrounding environment in front of us. So, our human image is a very good example of the remote sensing technology. So let us discuss the effect of the atmosphere because as we have understood the light sources is basically in our remote sensing is basically the Sun okay.

So, Sun light is traveling through the atmosphere, then it is interacted with the earth surface or the specific object that we are going to monitor and then again reflected back to the space and here. So, during that process it is traveling through the atmosphere again reflected back through the atmosphere. So, the atmosphere has a big role to play okay. So, there are certain things that we have observed that due to that presence of the atmosphere, due to the interaction with the atmosphere, there are some amount of error, there are some kind of aberrations, or there are some kind of effect observed on the remote sensing imagery. So, we have to identify what are the effects so that the technical things can be adopted so that we can remove those are the errors and fault.

So, understanding this atmospheric error is very very crucial in electromagnetic spectrum for which electromagnetic spectrum how it is reacting to understand or better understand the remote sensing technology and remote sensing image. So, the atmospheric constituent basically nitrogen, oxygen, vapor and there are so many gases presence in the atmosphere.

It has basically a typical characteristics with the wavelength spectral information. So different wavelength have a different kind of absorb observation characteristics as well as the scattering characteristics. So, these effect basically degrade the image quality.

So, the, some atmospheric effect can be corrected prior to further analysis and it is required. So, this is basically the example how the scattering takes place and the observation takes place in the atmosphere. So certain wavelength bands are strongly absorbed by the atmosphere. Based on the data for the last 30-40 years, we have observed that a specific band of a particular wavelength or a particular spectrum is very much absorbed by the atmosphere, and part of it part of the spectrum is not absorbed by the atmosphere. So, there is some, there is some window basically.

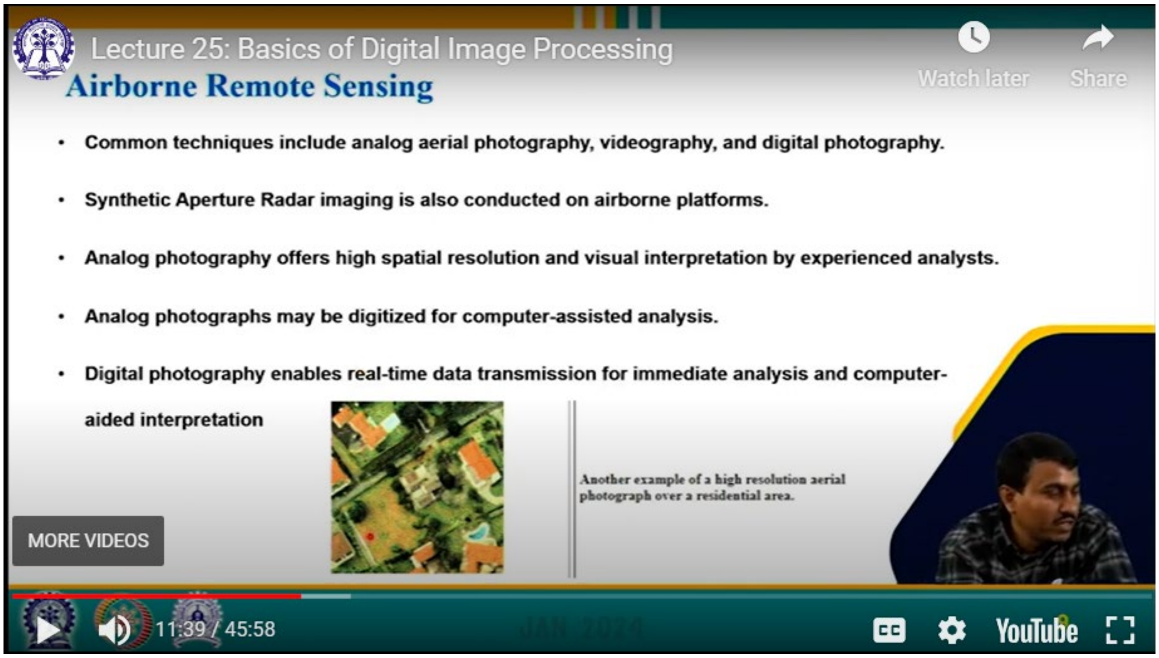
So, this window is basically the transmission window. So, the region of electromagnetic spectrum usable for the remote sensing are determined by the atmospheric transmission window. So based on the experiment conducted now for the for the analysis for the data recording the design of the space shuttle sensors we basically dedicated and we have basically stick to those transmission windows. So that effectively we can capture the useful information from the art. So, the remote sensing system are designed to operate within these transmission window.

So, the transmission window exit in microwave some infrared visible and near ultraviolet region. But for the x-ray and gamma-ray, it is transparent to the atmosphere, so there is no effect, and it is not commonly used in remote sensing in the art. Airborne remote sensing. One of the one of the popular method of the remote sensing is basically the airborne. There is a space there is a, there is a flight or aircraft, and on the aircraft there is a remote sensing sensor is mounted and basically it captures the image about the earth and not the earth object.

So, the advantage is because of the low, low flying height, it can acquire a very high-resolution image, high spatial resolution image. For example, here, we have shown that it is around 20 centimeters of spatial resolution. So, the disadvantage is because of the cost involved in flying an aircraft designing the sensor. It is low coverage, so it is basically high cost per unit area and low coverage. So, for the mapping of a large area in the in the art it is not very much cost effective compared to the other available remote sensing technology, for example the, satellite remote sensing. So, the earth observation satellite allow continuous monitoring. For continuous monitoring we need to fly continuously the the aircraft and that is again costly.

So, this is a particular image it is been captured you can see very high level of information you can see even the canopy of the trees are visible what kind of trees there based on this information we can process. This is the advantage of the airborne remote sensing system and their data. So, this is basically the way an aircraft travels and move above the earth and captured a particular area of interest. So, the common technique includes aerial photogrammetry photography and the videography and digital photography and synthetic radar imaging is also conducted on airborne platforms and analog photography offer high resolution high spatial resolution means and visual interpretation by experience analysis. An analog photograph can be digitized for computer assisted analysis and the digital photography enables real-time data transmission or immediate analysis and computer aided interpretation.

So, this is another example of the high-resolution image this basically captured on a residential area by the airborne remote sensing method. So very high level of detail can be seen from this particular image. Spaceborne remote sensing this is most popular globally and many countries and many associations of countries basically already floated different remote sensing satellite in the air for different purposes. So, in spaceborne remote sensing sensors are mounted on board a spacecraft space shuttle car or satellite that is orbiting around the earth continuously okay and at different altitude based on the necessity. So, at present there are several remote sensing satellites providing imagery for research and operational applications spaceborne remote sensing provides the following advantage and one of the big area of application is our communication technology is basically now hosted by the remote sensing basis spaceborne satellites.



Large area coverage because it has altitude is very high and it has a large field of view and frequent and repetitive coverage of an area of interest because it is it has a cycle time that it revisit the same place of the art in a some in a some time. So, you can acquire that data of that particular area of interest at intervals of that particular interval. Quantitative measurement of ground features using the radiometrically calibrated sensor. So, the sensors are radiometrically already calibrated and semi-automated computerized processing and analysis. Relatively lower cost per unit area of coverage because it's cover a high area and maintenance is the cost is also low once you floated it will serve at least for few years.

So overall, the running cost or the cost per unit area is less compared to the aircraft that you are basically utilising for getting the remote sensing data. Digital image. An image is a two-dimensional representation of object in real scene and in detail we have discussed in the last lecture about different terms and technology used in digital image processing. So, the, remote sensing images are representations of a part of the earth surface as seen from the space or the aircraft or the satellite sensor. The image may be analog or digital so the aerial photography are example of the analog for images while the satellite image acquired using the electronic sensors are example of the digital image.

Multi-layer image. So, the different type of measurement can be made from the ground area covered by a single pixel with different different bandwidth of the spectral band that is used for acquiring the image for each and every pixel level. So, each measurement forms an image carrying specific information about the area. So, stacking those image together one by one it basically forms a multi-layer image with each component image as a layer. So, a multi-layer image can be formed by combining images from different sensors and other data. For example, a multi-layer image may include layers from spot multispectral images, ERS synthetic aperture radar images and a digital elevation map of the same area.

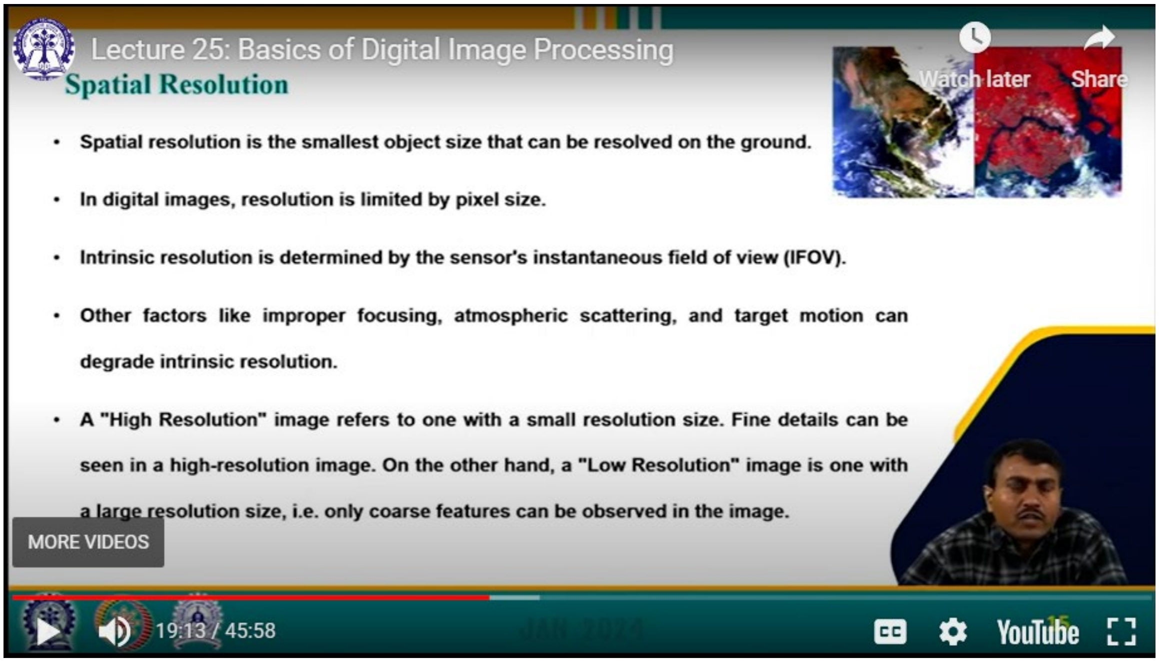
So, we can stack one after another of that area. So, from single pixel level we can get lot many information about that pixel their characteristics. So that is one of the advantages and that is because of that the multispectral imaging technique is also come into and it is very much used. So, it is basically multispectral image consists of multiple layers each representing a specific wavelength band. For example, a spot HRV have three bands, ICONOS have four bands, and the Landsat TM have seven bands.

Super spectral image. So modern satellite sensors like MODIS or NASA's Terra satellite have many more wavelength bands and MODIS consists of 36 spectral bands covering a wide range from visible to thermal infrared, and these sensors capture finer spectral characteristics with narrower bandwidth and such sensors are termed super spectral. Hyperspectral image. Hyperspectral image consists over a hundred contiguous spectral bands. So, in multispectral, we have seen a few 30 and 36 as the maximum you have seen.

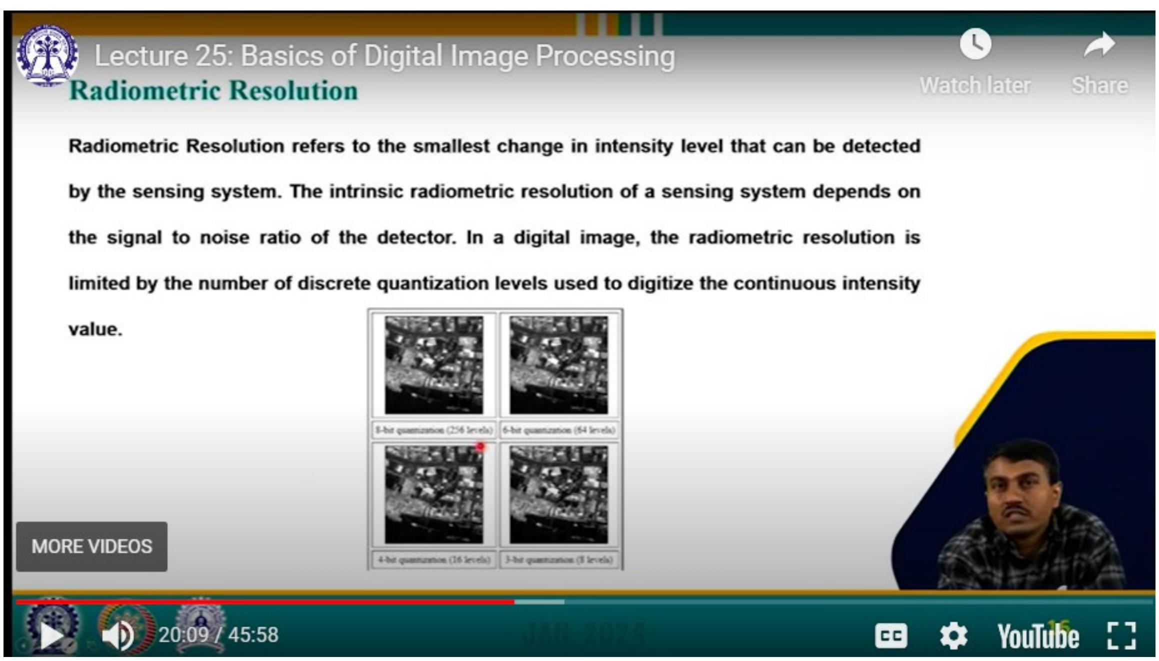
So, it is a few hundred. So, it has subdivided the bandwidth in a very small bandwidth so each bandwidth acquiring information so layer size for the hyperspectral image is huge. So, these images capture the characteristic spectrum of each pixel. So, we are we are getting a much much higher information compared to the multispectral imagery through the hyperspectral imagery technique. So, the precise spectral information enables better target characterisation and identification. Hyperspectral imagery finds application in precision agriculture and coastal management.

Currently no commercially available hyperspectral imagery is available from the satellite but experimental data is available from the NASA's Hyperion and ESHR is acquired hyperspectral imagery for scientific investigation. Spatial resolution. The spatial resolution is the smallest object size that can be resolved on the ground. In digital images, resolution is limited by the pixel size. The intrinsic resolution is determined by the sensor's instantaneous field of view, that is, IFOV, and other factors like improper focusing atmospheric scattering and the target motion can degrade the intrinsic resolution of the image.

A high-resolution image refers to one that have a very small resolution size. For example, centimeter level of few centimeter level and fine details can be seen in high resolution image finer details. Whereas for the low-resolution image is basically it is a large resolution size maybe meter few meters 20 meter 30 meter and only coarser features can be observed in the image. This is an example of a high-resolution image of the coastal area, and you can see that even the details of the atmospheric disturbances and cloud is also captured in this particular image. Radiometric resolution. Radiometric resolution refers to the smallest change in intensity level that can be detected by the sensing system.

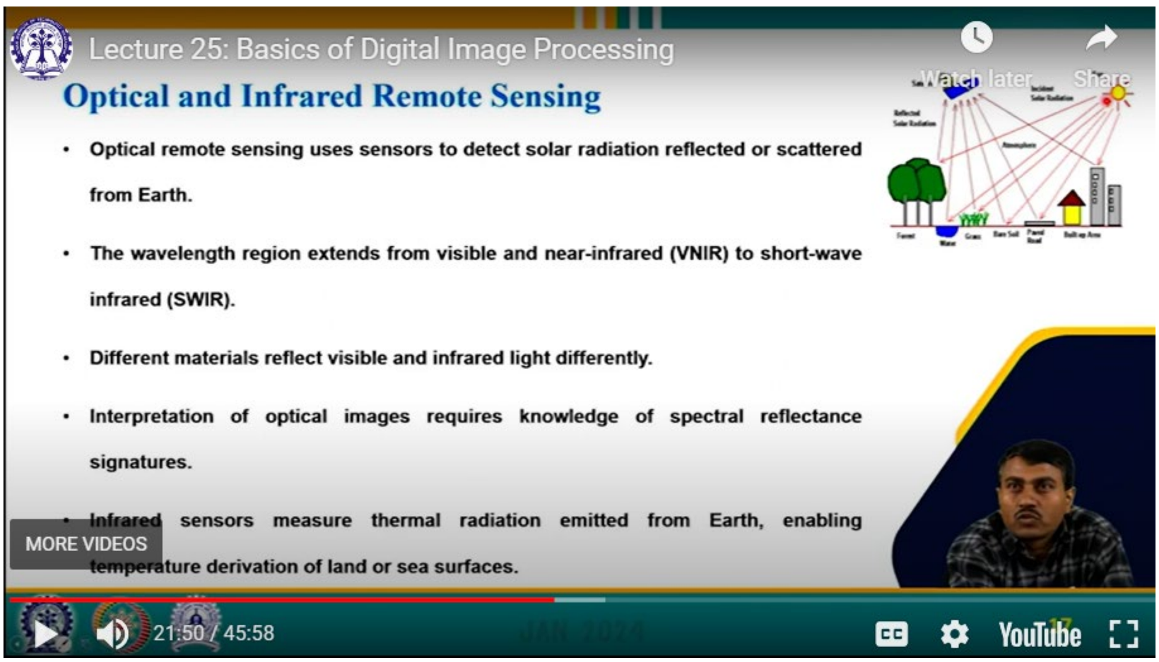


The intrinsic radiometric resolution of a sensing depends on the signal-to-noise ratio of the detector. In a digital image, the radiometric resolution is limited by the number of discrete quantization levels used to digitise the continuous intensity value. For example, here, 8 bit has a level of 256 2 to the power 8, 6 bit 2 to the power 6 that, is 64 level, 4 bit 2 to the power 4 that, is 60 level and 3 bit 2 to the power 3 that, is 8 level only. So, the radiometric resolution is very high for the 8-bit quantization so, obviously because it has a higher amount of information within the same area.



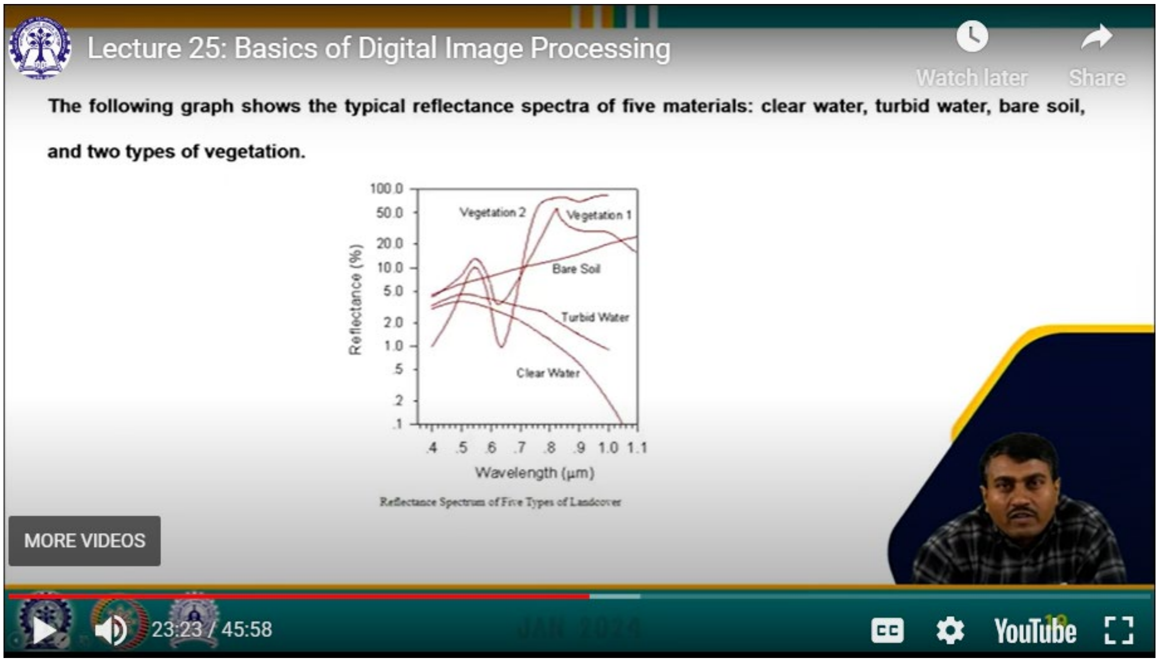
Optical and infrared remote sensing. Optical remote sensing uses sensors to detect solar radiation reflected or scattered from the earth. The wavelength region extends from the visible and near-infrared to shortwave infrared SWIR. The different material reflects visible and infrared light differently. An interpretation of optical images and require knowledge of spectral reflectance signature. So, different material have different spectral signature and they are different observation characteristics.

And based on the spectral reflectance we can identify that these reflectance characteristic is basically from those kind of object. So those reflectance characteristics and the signature is already known and based on the data we basically classify the object from these kind of imagery. So infrared sensor measures thermal radiation emitted from the earth and enabling temperature derivation of land or sea surfaces. So, this is the typical example. So, the Sun is a source of electromagnetic spectrum that interacts finally through the atmosphere to the earth's surface.



There are buildings, paved road, bare soil, vegetation, water and the big trees and they have different different reflection characteristics and data is acquired by the satellite. So, there would be different kind of data, different kind of signature it will collect. So based on that signature, we will identify, okay, this is the building, this is the paved road, this is the vegetation like that. Spectral reflection reflectance signature. When solar radiation hits a target surface it may be transmitted, absorbed or reflected.

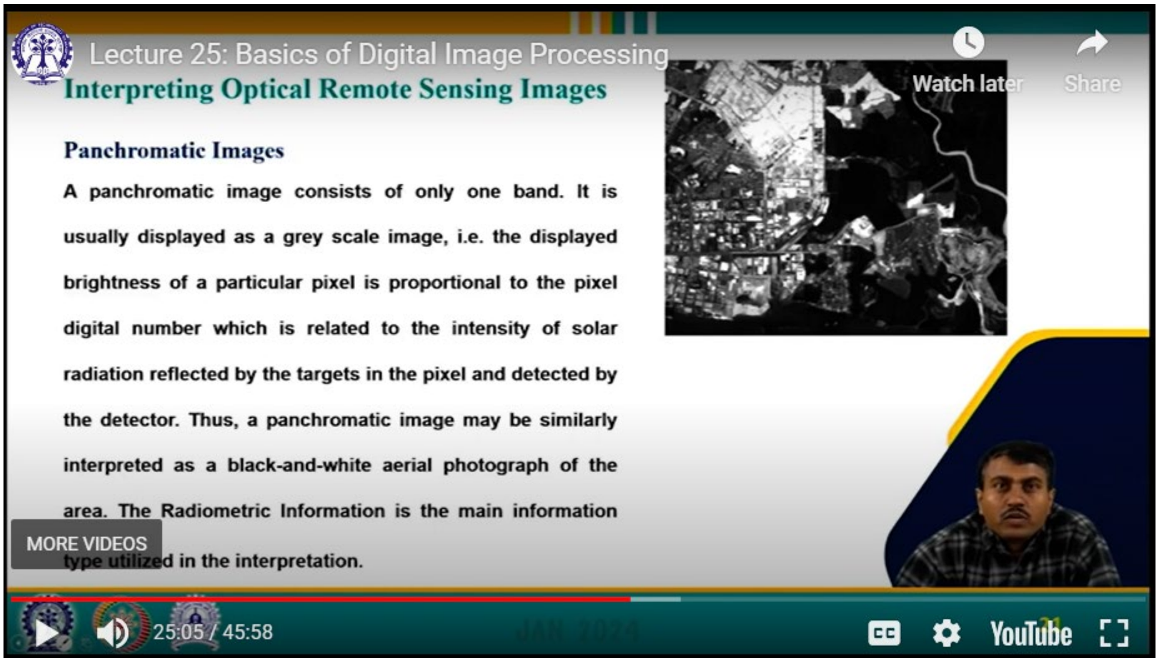
So different material reflect and absorb differently at different wavelength and the reflectance spectrum of a material is a plot of fraction or a of radiation reflected as a function of the incident wavelength and serve as a unique signature for material. In principle, a material can be identified for its spectral reflectance signature if the sensing system has sufficient spectral resolution to distinguish the spectrum from those of the other materials. These premises provide the basis for multi-spectral remote sensing. So, this is basically the graph that shows different reflectance spectra of different materials. Here five number of materials are being assumed and shown.



Two type of vegetation, so the reflectance characteristics is high in the vegetation. Bare soil have a little less, turbid water much less and clean water or clear water does not have a reflectance value or nearly zero or like that. So, this is basically the reflectance characteristics of different materials. So based on these data satellite imagery data can be interpreted that these basically based on the data we are seeing that this could be the bare soil this could be the vegetation like that.

Interpreting the optical remote sensing image. So, four main types of information contained in an optical image are often utilised for image interpretation. That is the radiometric information, brightness intensity and the tone depends on the level of the bit size. So it, basically for the higher bit size, it can store higher brightness values, and it can it can see in a much detail about the information about the object. Spectral information color and hue then the textural information about the object and the geometric and the contextual information or the surrounding geometric and contextual information of that image.

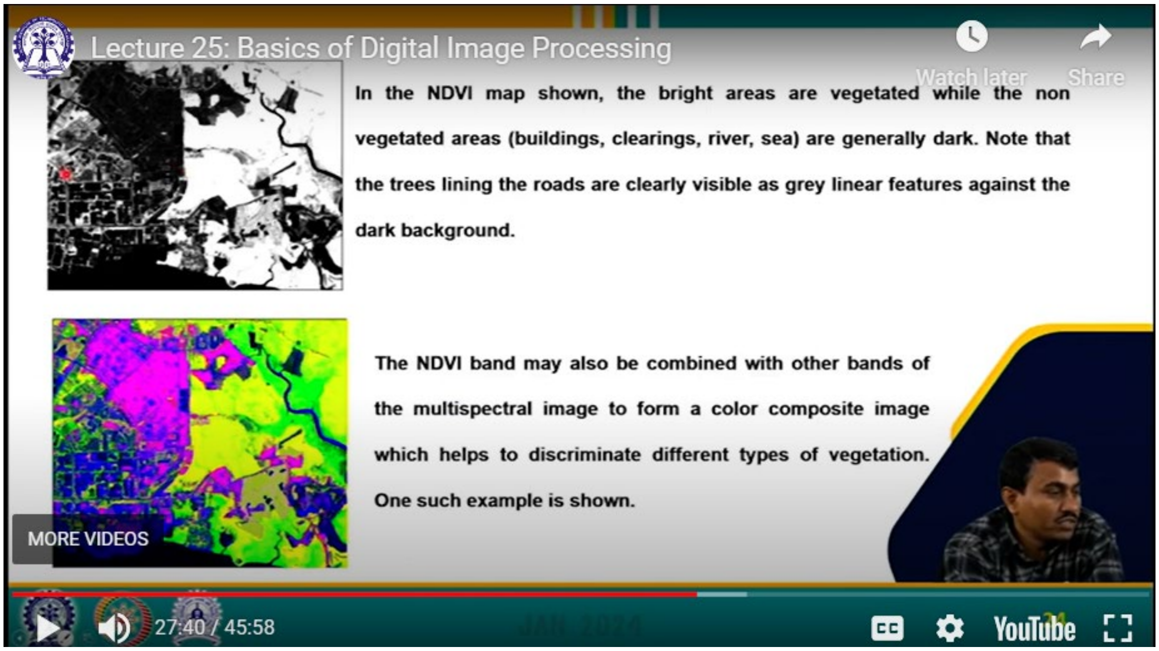
Interpreting again with the panchromatic images. A panchromatic image consists of only one band and it is usually displayed as a grayscale image and that is the displayed brightness of a particular pixel is proportional to the pixel digital number which is related to the intensity of solar radiation reflected by the target in the pixel and detected by the detector. So thus, the panchromatic image may be similarly interpreted as a black and white aerial photograph of the area. The radiometric information is the main information type utilised in the interpretation. True colour composite. So, if a multispectral image consists of three visual primary color band red, green and blue the three bands may be combined to produce a true color of the image.



For example, band 1 is the blue, band 2 is the green, and band 3 is the red of a Lancer TM image or iconos multispectral image can be assigned respectively to the RGB colors for display. So, in this way the color of the resulting color composite is basically resemble closely to the what we have observed through the naked eye from the art. So, it is basically creating a kind of same kind of picture that can be seen through the human eye. Vegetation indices. This is a very useful method to understand the growth of the vegetation as well as to assess the agricultural production nowadays is very much in use.

So, different bands of multispectral image may be combined to accentuate the vegetated area. One such combination is the ratio of the near infrared band to the red band. So, this ratio is known as ratio vegetation index. This is nothing but the NIR by the rate. Since vegetation has high NIR reflectance value but low-rate reflectance vegetated area will be a higher RBI value compared to the non-vegetated area.

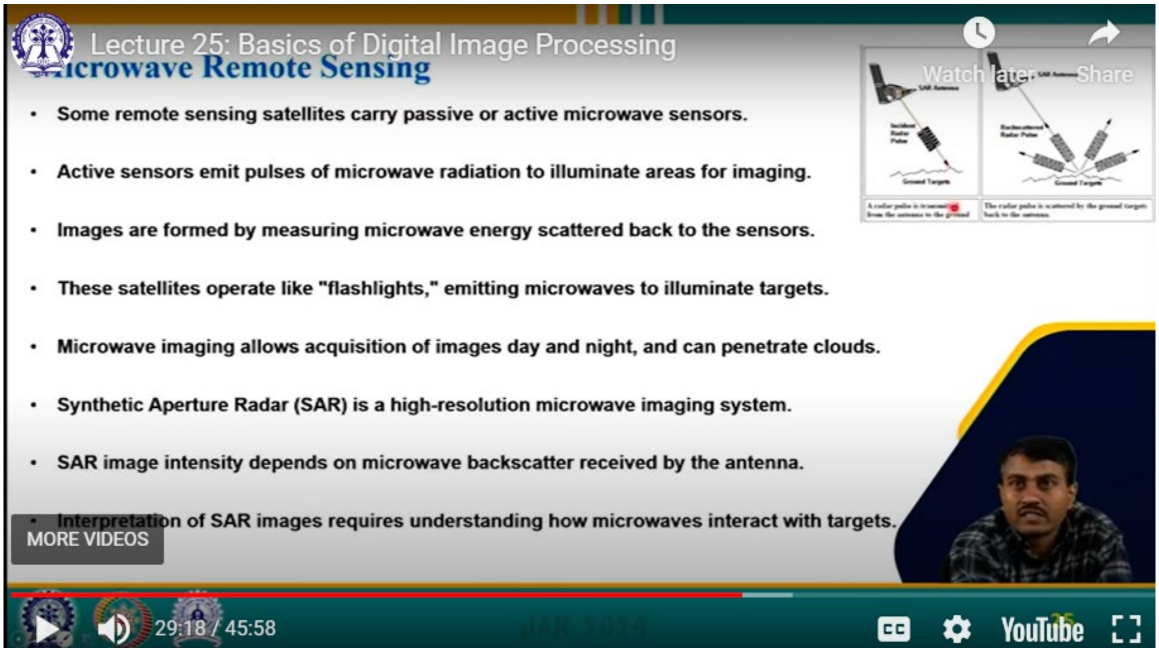
So, another commonly example is used vegetation index is the normalised difference vegetation index NDVI. This is basically NIR minus rate divided by NRI plus rate into area. So, this is basically the NBDI map shown above basically the vegetated area is shown as a white okay and or the other portion is dark. So, the tree lining in the road basically shown as a visible gray line and feature against the dark background. Whereas we when we basically combine that same image with the other bands of the multispectral image to form a color composite of the image.



This basically describe the different types of vegetations of this particular area. So much more information we are getting from the multispectral image of that particular area. Microwave remote sensing. Some remote sensing satellite carry passive or active microwave sensor. Active sensor emit pulses of microwave radiation to illuminate area for imaging.

Images are formed by measuring microwave energy scattered back to the sensor. Technology is more or less the same. So, the satellite operates like a flashlight. Those are the active microwave remote sensing satellites emitting microwaves to illuminate the target. Microwave imaging allows the acquisition of images day and night and can penetrate the cloud. Synthetic aperture error is a high-resolution microwave imaging system.

SAR image intensity depends on the microwave backscatter received by the antenna. An interpretation of an SAR image requires understanding how microwaves interact with the target. So, this is basically the active microwave remote sensing. So satellite emits the radar pulses hits the ground surface and ground surface interact differently part of the wave reflected back again to the SAR antenna it's received and based on that it basically captured the image about the surface or the object. So electromagnetic radiation in the microwave region is used in remote sensing to provide useful information about the Earth's atmosphere, land, and ocean.

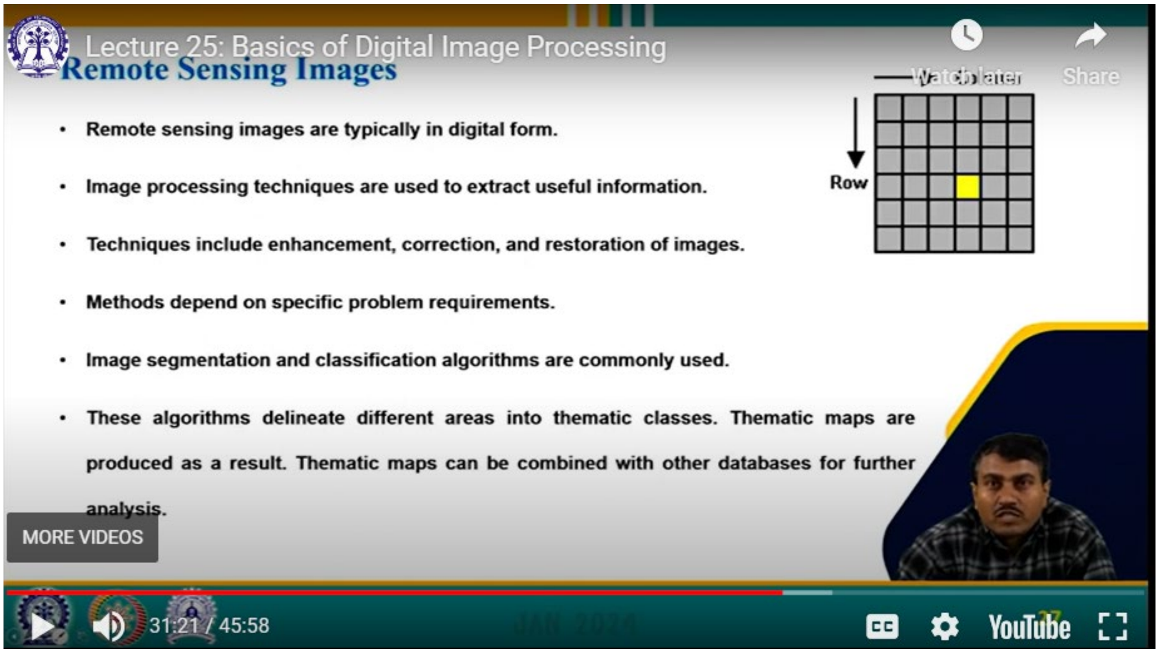


So, a microwave radiometer is a passive device that records the natural microwave emission from the earth. It can be used to measure the total water content of the atmosphere within its field of view. A radar altimeter sends out pulses of microwave signal and records the signal scattered back to the from the earth's surface. The height of the surface can be measured very accurately from the time delay of the return signal. A wind scatterometer can be used to measure wind speed and direction over the ocean surface.

So, it sends out pulses of microwave along several direction and records the magnitude of the signal back scattered from the ocean surface. Remote sensing images. Remote sensing images are typically in digital form. So, image processing technique are used to extract the useful information and the technique includes enhancement correction restoration of the images.

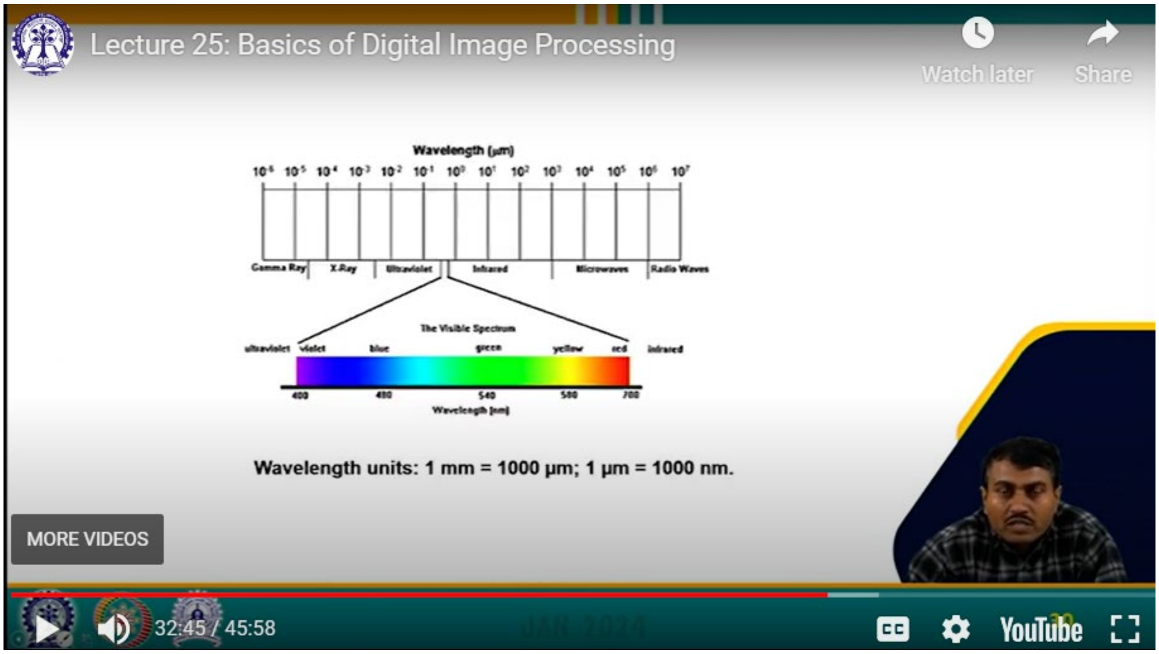
Methods depends on specific problem requirements. The image segmentation and classification algorithm are commonly used. These algorithms delineates different areas into thematic classes. The thematic maps are produced as a result. The thematic maps can be combined with other database for further analysis.

So, this is a two-dimensional remote sensing image. There are row and column and the yellow color represents the brightness value of that particular pixel. Electromagnetic radiation. So electromagnetic radiation is nothing but an electromagnetic wave travels through the atmosphere and these electromagnetic wave have a very specific speed that is the speed of light 2.99 into 10 to the power 8 meter per second and this speed of light is basically frequency into wavelength.



So, this is the typical nature of the EM spectrum. The frequency of an electromagnetic depends on the sources. There is a wide range of frequency encountered in our physical world ranging from low frequency of electrical waves generated by the power transmission line to very high frequency of gamma ray originating from atomic nucleus. These wide frequency range of electromagnetic wave constitute the electromagnetic spectrum. So, the electromagnetic spectrum comprises various wavelength regions. Only a narrow band from 400 to 700 nanometer is visible to human eye and boundaries between these regions are approximate and can overlap and there is no sharp boundary between the adjacent regions.

So, this is the typical pictures of the EM spectrum. Only the visible spectrum is shown here from 400 to 700 nanometers. So, 1000 nanometer is basically 1 micrometer and 1000 micrometer is basically is 1 millimeter. Image pre-processing. So, once an image is acquired, it is generally processed to eliminate errors.



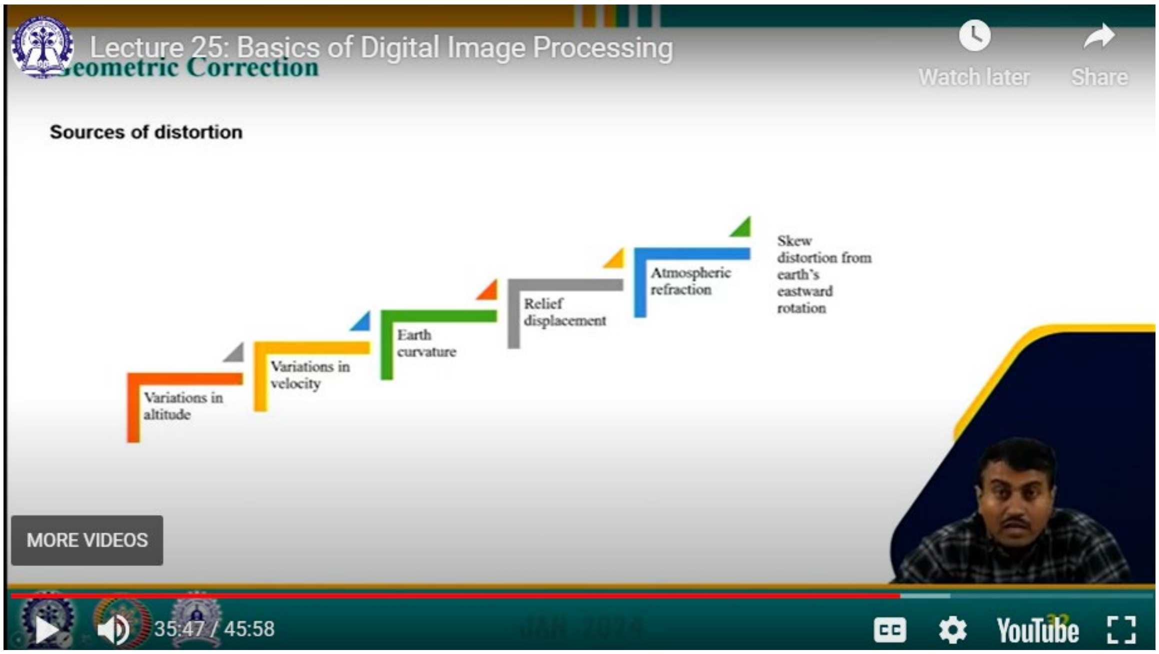
So, there are two types of errors that we have to remove. One is a geometric error we have to remove, that is, geometric correction and the radiometric correction. The geometric correction sources. So, this is a variation in altitude. So, satellites that acquire the image of the spacecraft that or the UV that acquire the image it cannot always operate with a very fixed altitude height. So, there are certain amount of change in the in the altitude of that particular sensor.

So, because of that, some kind of error will be there, and that is basically a kind of geometric correction required on that. Then, variation of the velocity. The velocity is also not constant over the over the traverse range. So, because of that also, some kind of error will be incorporated in the image, and we need to remove that.

Then, earth curvature. Earth is a curved surface. So, for a large area, earth curvature error is there, and we have to remove that. For a small area we can ignore this particular area. Then relief displacement because earth surface is a basically not very plain. So there are some ups and downs. Suppose for example in the mining area there are open pit mines different benches are there deep.

So on the surface and the open pit deep the image correct collected by the satellite is from the same height. So there are relief displacement correction is required because satellite is operate from the same height. There are ground level. There are ground level of the peak bottom level.

So these basically different maybe 100 or 100 to 200 meter level difference. So level relief correction is required on those cases. Atmospheric refraction correction is also required because a different wavelength different spectrum have different kind of refraction characteristics and the skew distortion from the earth eastward rotation because when you are capturing the image earth is rotating on its own axis okay. So earth is moving, so when the image is captured, if for few hours the imager is taken in the meantime earth rotates eastward.



So there are some amount of error that may be associated with that kind of phenomena. So, these are the possible correction error sources of the geometric correction. So we can apply some algorithms. We can apply some mathematics to remove those errors. So, the raw digital image can contain two types of geometric distortion.

One is systematic, another is random. So, the systematic errors are understood and can be corrected by applying formulas. But for the random error, it is very difficult to remove, and the only method is the ground control points. We have to install ground control points in the UAV imaging. There are some data for an 1 square kilometer area we basically install 8 to 10 number of ground control points and by that we are basically removing the errors okay. So, following a multi-regression multiple regression technology and using the ground control points, we are basically removing the error.

So random error removing the random error is very, very complex, and even after that, some amount of error will remain in the data. Radiometric correction. So radiance measure at a given point is influenced by the change in illumination because illumination is not constant; suppose at 10 a.m. at 12 p.m. or 1230 p.m. or 130 p.m. is not the same. Atmospheric conditions haze and cloud some cloud may come in between during the data acquisition. Angle of view at what angle the sensor is acquiring the data that is also important and what place of the art you are acquiring the data that is also important. Instrument response characteristics sensor characteristics also important and the elevation of the sun seasonal change in the sun angle same is not there in the case of winter or the monsoon or in the summer. So that elevation is changed sun angle is changed in the northern side as well as on the southern side and the earth-sun distance is also not fixed throughout the year that basically changed.

So, these are basically the possible sources of the radiometric errors. Image enhancement. So, improving image quality, particularly the contrast it, includes a number of methods used to enhance the subtle radiometric differences. So that I can easily perceive them. Two types: one is the point; another is the local operations. So, the point operation is basically modifying the brightness value of a given pixel independently without considering the value in the region.

Local is basically modifying the pixel brightness based on the neighborhood brightness values. Image enhancement three types of manipulations are. There one is the contrast enhancement it refers to method includes gray level slicing and gray level thresholding and the contrast stretching. Special feature manipulation method includes spatial filtering, edge enhancement and the, Fourier analysis and the multi-image manipulation. This includes the multispectral band ratioing, differentiating, principal component analysis, canonical component analysis and vegetative components, de-correlation stretching and others methods. Contrast enhancement the image on the left side here it is shown is basically shown some amount of atmospheric backscattering effect on this image and these right side image is basically now restored image improved image following a gray level thresholding methods. So that basically gives a better picture and better features better way we can extract the features from this particular restored image.

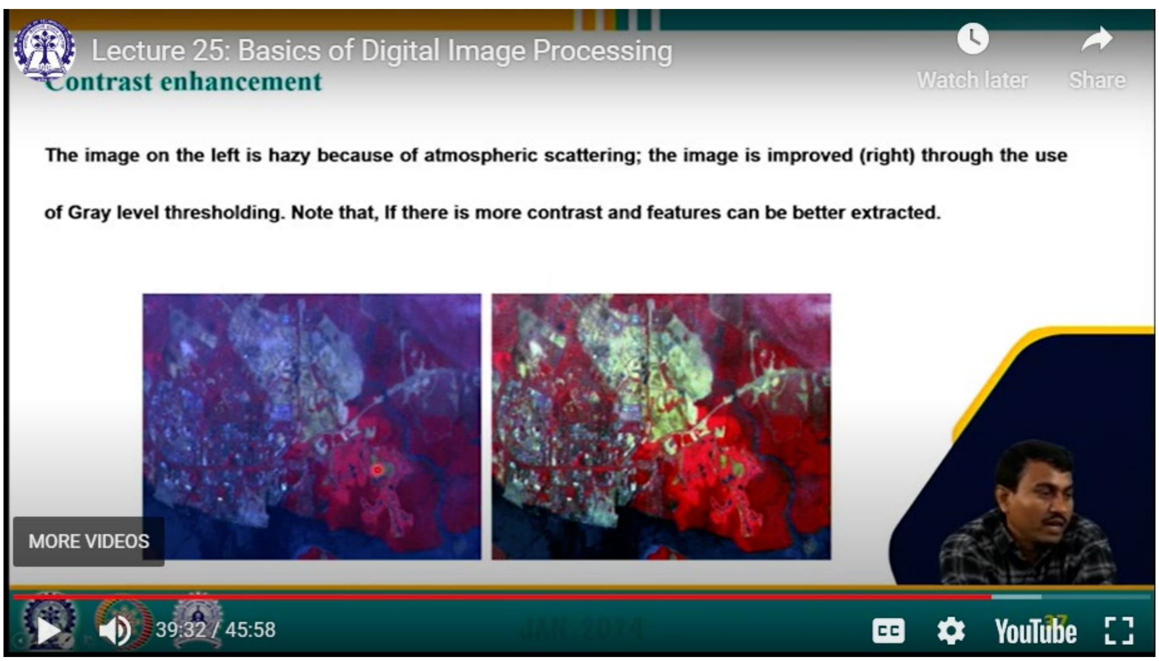


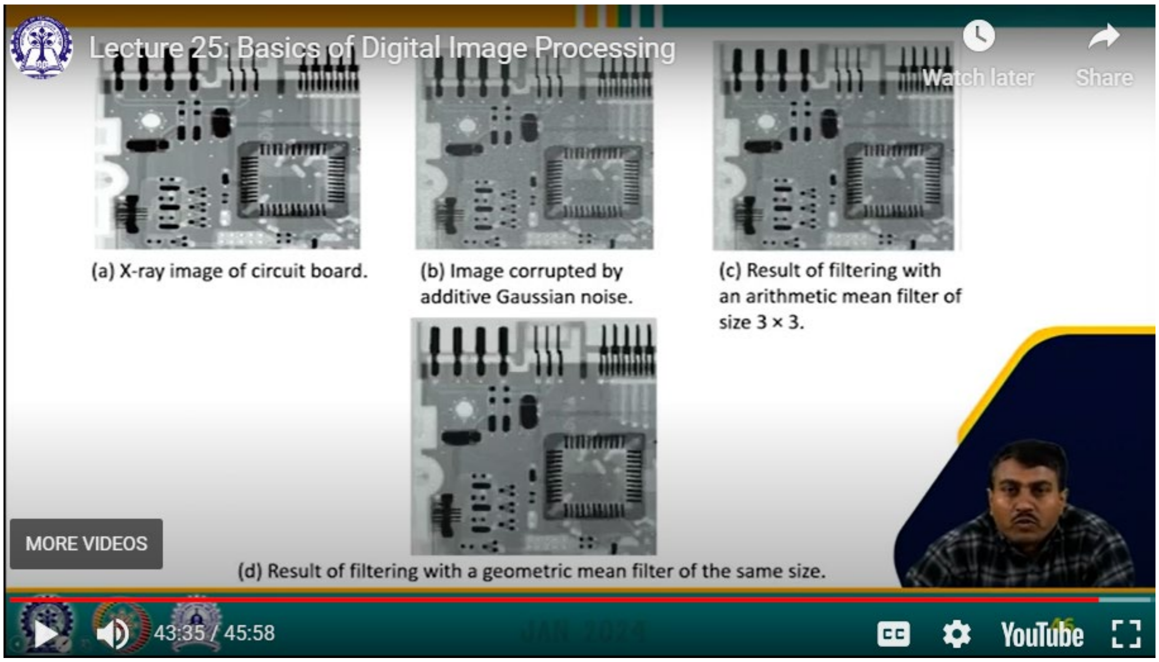
Image classification one is the spectral pattern recognition second is the spatial pattern recognition and third is the temporal pattern recognition. So spectral pattern recognition classify a pixel based on its pattern of radiance measurement in each band more commonly and easy to use and spatial pattern recognition classifies a pixel based on its relationship to surrounding pixel more complex and difficult to implement. And the temporal pattern recognition basically looks at change in pixel over time to assist in feature recognition. Spectral classification two type of classification one is supervised the analyst designate on screen the training areas known land cover type from which an interpretation key is created and describing the spectral attributes of each cover class. And the statistical technology are used to assign pixel data to cover class and based on what class its spectral pattern resembles.

Second is, the unsupervised automated algorithm produce spectral classes based on natural grouping of multi-band reflectance value rather than through the designation of training areas, and analyst use reference data such as field measurement, DOQ or GIS data layers to assign areas to the given class. Unsupervised computer groups all pixel according to their spectral relationship and, looks for natural spectral grouping of pixel called spectral classes, and assume that the data in different cover classes will not belong to the same grouping. Once created, analyst assess their utility. Image restoration the restoration technique are oriented towards modeling the degradation and applying the inverse process in order to recover the original images.

Noise model digital images can be affected by the noise during image acquisition or transmission. So, imaging sensors performance is influenced by the environmental factor during acquisition and the quality of sensing element. The factors like light levels and sensor temperature can impact the amount of noise in image captured with a CCD camera. Transmission channel can introduce interference corrupting image during the transmission. Example of interference during transmission include disturbances like lightning or atmospheric condition in wireless network. So, this is basically the mathematical algorithm with the degradation method to the restoration by applying some filters.

So, there are kind of different kind of filters are also available. Mean filters arithmetic mean filters. So, the arithmetic mean filters computes the average value of the corrupted image g(x, y) in the area defined by S_{xy}. The value of the restored image f x at point of x y is the arithmetic mean computed using the pixel in the region defined by S_{xy}. So, this is basically the formula of the arithmetic mean filters. There are other filters as well geometric mean filters, harmonic mean filters and contra harmonic mean filters there are other filter also that basically used for restoring the image quality.

So, this is basically the x-ray image of the circuit board. Now, image corrupted by the additive Gaussian noise result of filtering with arithmetic mean size 3 by 3 and the result of filtering with geometric mean filter of the same size. So, you can see the difference of the output by applying different kind of filters. So, we have to select what kind of filters is suitable for a particular kind of image and the data. Image compression for transferring image to other devices or due to computational storage constraint image need to be compressed and cannot be kept at original size and it is equally applicable in the mining also because frequently we have to communicate the image. So, that is why image compression is very much required and those kind of algorithm is integrated in the connected mining concept.



So, that image can be transferred easily, and data can be captured. Morphological processing image component that are useful in the representation and description of the shape needs to be extracted for further processing or downstream task. For example, erosion and dilation operations are used to sharpen and blur the edge of an object in an image, respectively. Image segmentation, so this step involves partitioning an image into different key parts to simplify and or change the representation of an image into something that is more meaningful and easier to analyse. So, image segmentation allow for computers to put attention on the more important part of the image discarding the rest which enables the automated system to have improved performance.

So, these are the references

And let me summarize in few sentences what we have covered in this lesson. So, we have provided an overview of the remote sensing technology. We have explored various methods and approaches employed in remote sensing application, discuss the captured image using the optical, infrared and microwave technology remote sensing. Introduce the process of manipulation and enhancing remote sensing images just for analysis and, explore technique for improve the quality of degraded or damaged remote sensing images, and discuss methodologies for interpreting and extracting meaningful information from remote sensing images.

Thank you.