Remote Sensing: Principles and Applications

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Lecture – 18
RS Image Acquisition and RS Systems – Part 1

Hello everyone, welcome to the next lecture of the course remote sensing principles and applications. In this lecture, we are going to discuss how an image is acquired, what will be the geometric properties of images and so on.

That is until last lecture, whatever we discussed effectively dealt with the contents of the image, what we call the radiometric content of the image like what the image contains, DN; what is the actual physical property recorded in an image, radiance; what do we really need for our applications, reflectance; what are the factors that may affect the radiance and so on.

So, essentially we talked about the contents of the image DN, radiance, reflectance, some factors affecting them everything. In this lecture and in the coming few lectures, we are going to see how actually the image is recorded, how sensors work in space and due to sensors property, how the geometric accuracy of the image as well as the radiometric accuracy of the image will be affected.

So, geometric accuracy in the sense say, for any ground point x, y. Let us say, the coordinate of point is 100, 100. In the image, we will have a point of that particular ground point. We will be able to calculate, what is the ground coordinates of each image point that is possible. So, if we calculate that from the image also, we should retrieve back the same 100, 100 for the ground part.

If you are able to do that, the image is geometrically accurate and whatever feature that it should exactly look the same. Then only we see images geometrically accurate. Say, when we take our normal photographs, let us say, we are taking a photograph of a circle, if the circle appears as a circle in the photograph of similar size, it is fine. If the circle gets distorted, if it appears as an ellipse, then the image is not geometrically correct. There is some sort of geometric distortion.

So, all these kind of properties about how image is being recorded, how the sensor performs, how it affects the geometric accuracy of the image, how it affects the radiometric accuracy of the image, all these things, we will discuss. In addition to this, the most important concepts that we are going to discuss in this lecture, in the coming few lectures, are the different resolution concepts attached with a sensor and an image.

Each remote sensing system has certain characteristics given by the terms spatial, spectral, temporal and radiometric resolution. So, these are 4 important characteristic of any remote sensing system, spatial, spectral, temporal and radiometric resolutions. So, what are these? How these are related to image acquisition process? All these important concepts, we will cover in next few lectures starting from this particular lecture.

Before we move on to actually look at the procedure of image collection or image acquisition, we will first try to get a feel for what are the different class of remote sensing sensors are there, how remote sensing sensors can be classified. It is given in this particular slide.

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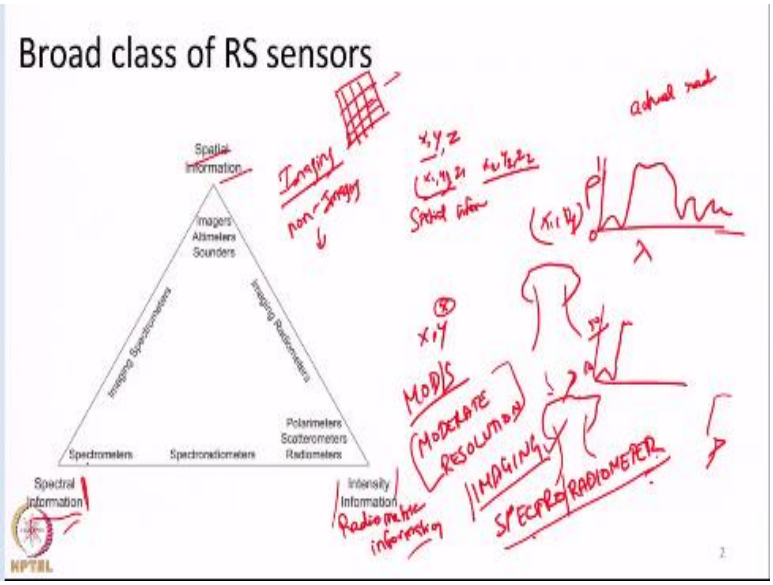

So, any remote sensing sensor can collect spatial information, spectral information and intensity information. Intensity information, we can also call it as radiometric information. Spatial information is data about any given ground point x, y. Say, for example, if I collect the elevation of all ground point x 1, y 1, z 1, x 2, y 2, z 2. if I collect such data at a given ground point, ground coordinate x, y, what is the elevation of the point?

If we collect this, I am actually collecting spatial information. On the other hand, at every ground point, if I collect, how the incoming energy or how the reflected energy varies with respect to wavelength, say there may be like a vegetation standing there in a given ground point x, y. There may be like a tree standing. What I am interested in collecting is, at the point x, y, what is the spectral reflectance curve.

So, at a given point x, y for this tree, how the spectral reflectance curve looks, this will vary from 0 to 1. If I collect such information, I am collecting spectral information. On the other hand, rather than collecting this reflectance value that is between 0 to 1, if I collect the actual amount of radiance, let us say, for this particular tree, the radiance recorded at green band is say, some 10 units or NIR band is say, some 50 units. So, if I collect the actual radiance recorded, actual energy that came in, actual energy that got reflected, if they measure it quantitatively, I call it radiometric information or intensity information. So, essentially, remote sensing is a process in which we do all 3 to some extent, we should collect information across the space across the x, y domain. We should collect spectral information at different bands, how much is the reflectance.

Also for various applications, we should also measure the actual radiance itself. Say for example, for some applications, it will be good for us to know only the reflectance values. Say for example, for this particular feature, 10% of incoming energy is in green; 20% of reflected energy is in NIR band. If I know this, that is sufficient. I may need not know what is the exact amount of energy came in.

Only the fraction or only percentage composition if I know, that is good enough. For some applications, I should know the exact amount of radiation that came in from different, different bands. So, it depends on the various applications we use. So, based on all these things in remote sensing, we may have to collect spatial information across a spatial domain, spectral information across different wavelengths and radiometric information which means the actual amount of energy that came in.

So, based on these 3 properties, the sensors may be classified into different, different classes. First thing is, any given remote sensing sensor can be imaging or non-imaging sensor. So, what is imaging or non-imaging sensor? As the name suggests, an imaging sensor produces a 2

dimensional image of any given area that is whatever it records, it records in a 2 dimensional space and gives an image as output.

Non-imaging sensors essentially do not create images, they just collect data at various discrete points. For our own understanding later on, we may create image out of it. What are such sensors? Let us take one class of sensor known as altimeters. Altimeters have the purpose of collecting the elevation information, say whenever it is flying, it will send some electromagnetic radiation either in microwave or in light energy LIDAR sensors.

They will send in some pulses, they will collect the signals back. Using this, they will calculate the height of the ground feature. So, they will give us x, y, z points. It is a series of points x, y, z, x, y, z and so on. If you display it in like image display system, you will get what is known as a point cloud maybe; at different x, y, what is the z? That is the only thing that will come up.

So, this sensor essentially do not provide a 2 dimensional image. It provides a series of points with x, y, z coordinate such sensors are altimeters or like radar altimeters, LIDAR altimeters, and so on. Similarly, atmospheric sounders, atmospheric sounders are some instruments which will look down the atmosphere. It will try to estimate the temperature, humidity, pressure etcetera at different, different elevations of atmosphere.

So, they will also essentially provide point information. At this (x,y), at this height of atmosphere, the temperature, pressure was this. At this (x,y) at this height of atmosphere the temperature and pressure and other variables are like this. They will provide such information. So, these kind of sensors atmospheric sounders, altimeters, etcetera, they provide spatial information non-imaging sensors.

Let us take an example of a Landsat satellite. Landsat satellite is a imaging sensor. It provides a 2 dimensional image. It collects data in multiple bands. So, it provides spatial information, spectral information and using Landsat data, we will also be able to calculate the quantity of the energy that came in. So, it collects all spatial, spectral and radiometric resolution.

One more example sensor, I will say is MODIS, is a very widely used sensor MODIS, full form is Moderate Resolution Imaging Spectroradiometer. Just look at the name, Moderate

Resolution, it just deals with the resolution of the feature. We will learn about it later. Imaging, the sensor will provide a 2 dimensional image that is known. Spectroradiometer, the sensor collects data in different, different spectral bands.

Also, it collects the exact amount of energy that is coming out of a sensor. So, it is both a spectrometer as well as a radiometer. So, it is an imaging spectro radiometer, it does all the jobs, spatial information, spectral information and radiometric information. Like some instruments like spectrometers, some instruments, which we will use in our hand for collecting ground data, they may not collect the exact amount of energy that came in.

They may collect only the relative variation of spectral reflectance. In this band, this is 10%; in this band, this is 20% only the relative variation that will measure. Such instruments are called spectrometers. Some instruments like say for example, during time of COVID and all, people used to point hand held thermometer. Remotely, they will keep it towards our eyes. What the thermometer will do?

It will collect the radiation from us, using that it will calculate the temperature of our body. That is essentially a pure radiometer. It is not doing any sort of spatial data collection or any sort of spectral data collection. Purely, it is measuring the incoming energy. What is the quantity of incoming energy? Using the quantity of energy, it is calculating temperature of our body that is a pure radiometer, from radiometric information it is doing something.

So, the sensors can be collecting spectral, spatial and radiometric information. Most of the remote sensing sensors especially what we deal in our class, like Landsat, MODIS, Indian remote sensing satellites, some of the examples what and all, we will see. Essentially they collect all the information, they collect spatial, spectral radiometric information. They all fall in the category of imaging spectrum radiometers. They collect image; they collect spectral information; they collect radiometric information.

Next, we are going to start with remote sensing data acquisition. Like now, we learned to a good amount of, good extent that once the image is collected, how are different, different processing we can do especially in the visible, NIR and SWIR wavelength. It is λ less than 3 micrometres. We have a good knowledge at this point. How that image is collected? How it is being carried out? That is what we are going to see in the coming slides.

First, we will take an example of like earlier days, earlier days, there is not much of sophisticated sensors available. But a normal photographic camera was there. I am talking about like 18th century and all, so, photographic camera was there. So, essentially people, they put a photographic camera in balloon or they tie it under huge kites, under pigeons and all, they flew it in sky, took photographs of the ground surface.

So, essentially, the first modes of image collection that happened is like pure analogue photography that is given in this particular slide.

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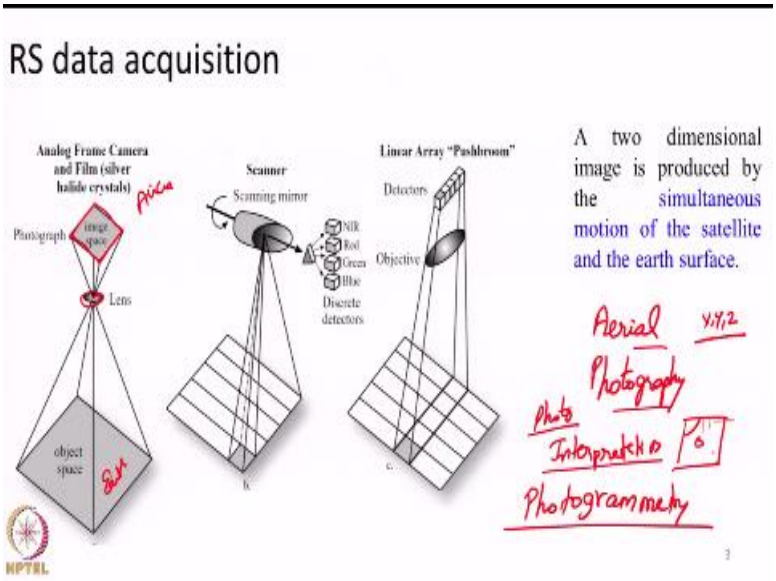

So, in olden days that will look something like this as given in the slide, say it would be like a photographic camera put in space, it will have a lens. So, this is earth's surface, it will take multiple different photographs. So, as the balloon or something moves, it will take multiple photographs. So, this was the earlier most ways in which earth observation was carried out.

Similarly, later people started putting such cameras in aircraft in order to collect aerial photography and using this, people did remote sensing based observations and they did what is known as interpretation. Just by looking at the photograph, they will tell us, there is a small urban settlement, that is like a water body and so on. So, this is known as photo interpretation.

This was very widely developed and used in days of World War. The people will fly the aircraft fitted with photo cameras. They will collect photographs and start interpreting it for collecting Strategic Defence information. And also, it gives us field what is known as photogrammetry,

photogrammetry essentially means making measurements from this photographs and mapping the features on earth's surface.

So, based on certain principles, if we take photographs, we will be in a position to calculate x y, z of all points that is imaged in that particular photograph. So, mapping the terrain, what is the x y, z coordinates, what is that particular feature is there. So, mapping everything measuring distances all these things develop, the technology developed and that particular subject is known as photogrammetry.

It is a different subject altogether, related field but there the much of the interest is in making physical measurements in photographs and mapping the terrain. So, olden days that is how aerial photographs were collected and measurements are made and also photo interpretation was done. Later came the age of space based satellite remote sensing. So, when something has to be sent to space, essentially, that particular sensor once sent, it cannot come back.

As people was still doing it, they will send something to space, it will fly in between like aircraft and spacecraft distances, it will come back, people will retrieve the tapes from it, develop it. It was possible, but still when fewer satellites was to be developed and sent to space, essentially, whatever data, is being collected by the satellite should be transmitted through some non-contact form, that is, you cannot bring the satellite down retrieved this film photography back and develop it as we do like a normal photograph.

Everything has to occur digitally and also the data has to be collected in a 2 dimensional space. We cannot send our normal photographic camera there. Then came the development of different, different sensors or different ways in which image was being collected. So, when the satellites was sent to space, there can be 2 different orbits or maybe first till the example of a normal still photography.

Let us assume, we need to take a photograph of a small surface or something that is happening in front of us. What we will do? That particular object or phenomenon will be there in front of us, we will take our camera, take a picture. So, our camera is actually stationary, we are standing still whomever or whatever object is there in front of us most likely will be standing still. We will take a photograph. We will get a 2 dimensional image.

If we think about like a satellite, satellite will be in continuous motion, it is imaging earth. Earth is also rotating continuously in some axis. So, these are some of the things which are in motion, this complicates things to some extent. So, in such circumstances, how the image was collected? First thing we should know is, based on the orbit of the sensor, the way in which the image will be collected will differ.

Orbit of the sensor means orbit in which a satellite is put up. 2 common orbits in which satellite put up is geostationary orbit and near polar orbit. Let us say, this is earth, satellite is revolving around it. So, if this is the earth, it will revolve from west to east, it will rotate like this. So, if the satellite moves around the earth in this direction, like from north to south, we call it as a near polar orbit.

There is another orbit called geostationary orbit in which earth is here, satellite will be placed along the equator at a farther distance as the earth rotates, satellite will also rotate with earth that is known as geostationary orbit. So, when satellite is put up in two different orbits, the image collection principle may vary little bit slightly. So, under these 2 circumstances, we will see how the images collected. We will see all these things from next class.

So, in this class as a summary, what we have seen is, we have seen the broad classification of remote sensing sensors which collects spectral information, spatial information and radiometric information. Then we just got introduced to the concept of how olden day photography was collected, how it was used for concepts of photo interpretation and also for photo measurements photogrammetry and so on.Next, we just got introduced to 2 different orbits, geostationary orbit or near polar orbit and from next class we will see how images are actually collected from these 2 orbits.

Thank you very much.