Remote Sensing: Principles and Applications

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Lecture-62
Land Use, Land Cover Monitoring and Change Detection-Part-1

Hello everyone, welcome back to the next lecture in the course, today we are going to start with the last part of the course, applications of remote sensing. Applications of remote sensing is an extremely wide topic to discuss. Because, whenever we want to apply remote sensing techniques to some applications, we need to have some sort of domain knowledge in that particular field, so that we can effectively use remote sensing datasets.

So, dealing with applications normally involve discussing the domain knowledge plus how remote sensing will help. So, we have to discuss both the things, which is a huge task actually, because there are plenty of different fields in which remote sensing is applied and it will be almost impossible to cover all applications and with the essential background knowledge required for us to apply the remote sensing data.

So, what we will see in this course is few basic applications in different fields. We will not go much deeper into it, this will give you a good flavor of different ways in which remote sensing can be applied; we will broadly touch different, different datasets, optical, active microwave, passive microwave and so on. With which you will be able to learn further and I will be giving a lot of references, along with this particular lecture, which will provide you like a good knowledge about the subject.

Today in the first applications part, we are going to start with land use, land cover monitoring and change detection. Actually land use, land cover falls under category of remote sensing image analysis. Here we will do certain analysis or certain operations over the satellite imagery, which will help us to categorize land use, land cover and also to understand or identify changes in the land. But, in this lecture we are not going to discuss those techniques, because that itself again will be very elaborate.

But I will just briefly tell you, what land use, land cover is? What are all the basic ways in which we can get it from remote sensing datasets? And some fields or some applications in which these land use, land cover datasets are directly applied, even without having much domain knowledge, we will be able to appreciate the way. Such examples we are going to discuss in the lecture.

First of all, what is land use and land cover? Land cover indicates the physical land type that is present on the surface, say vegetation, built up area, water body; these are all physical features that are present on the land. So, identifying them using remote sensing datasets is called as land cover mapping, whereas land use means, how we humans are putting that particular land parcel to use.

Say vegetation is a broad class, within that vegetation if someone is using the particular parcel of land for cropland. Then that classifies as land use. If there is a built up area, for what use that built up area is being put? Whether it is for residential purposes, for commercial purposes, industrial needs, plenty of different use we can put, that is land use. So, mapping and monitoring these are essentially carried out using remote sensing datasets. In olden days, people used to do ground based survey to collect such information. But after the advent of remote sensing, this has become very easy. Actually, identifying land use, land cover which is called as classification was one of the earliest applications of remote sensing, So, normally land use and land cover will go together, we will not be splitting them like this is the land cover map, this is the land use map. Normally, we will not do that. Whenever we identify something as vegetation, we will always identify whether it is crop land or forest or plantation, shrub land and so on. Similarly, whenever we identify a built up, we wil identify whether it is urban, rural, residential, commercial and so on, to some extent. So, both of them go together normally, and for various purposes we will be in need of such information.

The below slide is an example for a global land cover map obtained from MODIS sensor. So, this is produced yearly, here you can see there are like 17 classes together say blue colour parcels or water there are different classes of forest, grasslands, wetlands, crop lands and so on. So, this is just one example for land cover mapping and in this lecture we will see some uses of these sorts of maps.

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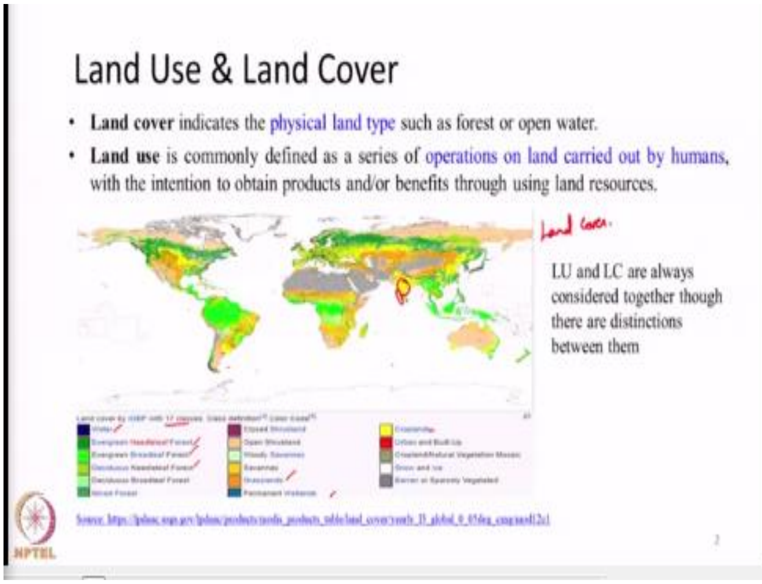

So, why LULC information is necessary?

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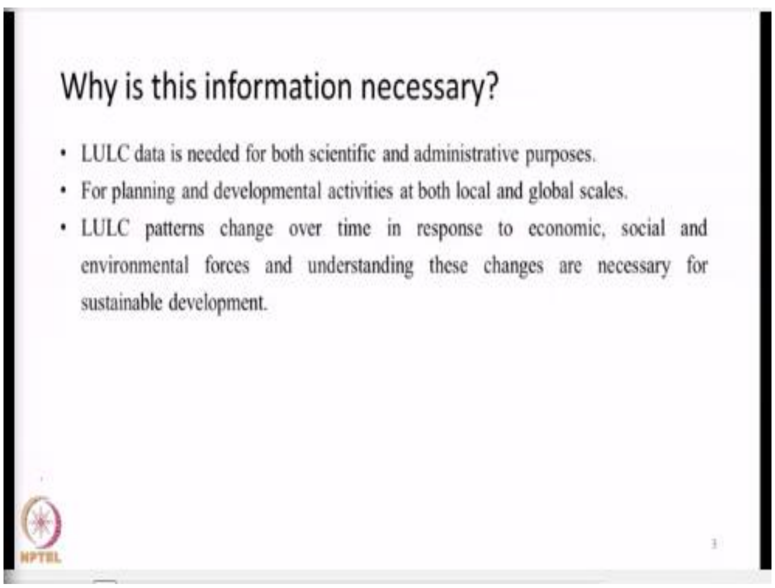

Land use, land cover data is needed both for scientific as well as administrative purposes. Say for example, someone needs to understand how the hydrological nature of a region has changed because of land cover change, say for example people might have built a huge residential apartments, they might have changed the characteristic of land cover or some forest are might have been cleared to introduce crop plants. When such thing happens normally there will be some change in other processes, like hydrological processes, ecological processes and so on. If we want to understand them, what is the effect of changing the water cycle in the region due to change in land use, land cover change? For that purpose we need, this was the older map , this is the new map, when the land cover change like this, what was the change in hydrology correspondingly? So, these are like scientific investigations.

Also, for administrative purposes say, a new airport needs to be developed, when you want to do a large scale infrastructure development, we should take a look at LULC map, identify a land that is empty. It is not being used for anything or whether there is any other plan for this particular parcel of land. So, it is a complex process, people will not just quickly go, this is the land I am going to start constructing airport, it is not going to happen like that. So, for identifying where to develop and if we develop something whether it will be useful to public. So, the airport should be not very far from the city, it should not be like 2 to 3 hours drive from the city, it should be close to the extent possible. So, there are like plenty of different planning has to go through when such large scale infrastructure projects come up. So, for such things definitely land use, land cover map will be needed.

In addition to this, due to normal human activity, LULC pattern changes over time in responds to our own needs and demands. So, when this happens, it will have its own impact in the natural cycles like ecological processes as I told like water cycle, even like climate and so on. So, understanding the effect of this change also is really necessary for sustainable development. We cannot go on doing something which is causing lot of ecological damage. So, when this study happens, the land use changed from the last 20 years like this, because of this, such damage has occurred to the environment, so can we proceed further. So, such kind of decisions, it is both like scientific as well as administrative. So, not only LULC map at this instant, but also the change that occurred in the last say 2 decades or 3 decades is of vital need for both scientific as well as administrative purposes**.**

What is change detection? We have just gone through about LULC, so, what exactly change detection is, it is very simple, identifying what has changed between 2 time instances or different time instances say the last 30 years what has happened to the city. So, we can do a multitemporal analysis. Say, every year what has happened or every 5 years what has happened? Identifying such things is known as change detection. The changes that are happening in the land use, land cover is again going to impact our surroundings, our environment and whatever natural things that we are dependent upon, so this is also really important. When there is a large scale urban expansion or when a forest is cleared for agricultural use that will appear differently when you look from satellite. So, all these things are kind of clues for identifying, some changes happened. So, visually on looking into satellite images, we will be able to identify such changes.

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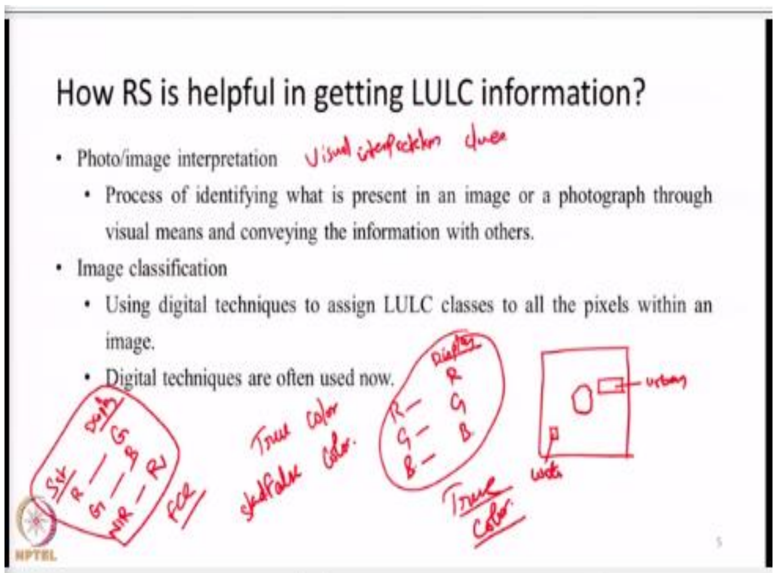

How remote sensing is useful in getting this LULC information or for change detection purposes? In the early days of remote sensing, people used to do visual interpretation. That means even before the advent of satellite remote sensing, in the days of aerial photographs are being taken. When we discussed about different platforms, I briefly told about taking photographs from aircrafts, kites or pigeons and so on. So, aircraft based photography's were widely used in earlier days, the technology developed rapidly during the world war times and people realized the civilian applications of such photographs. So, many developed countries had planned program of acquiring aerial photographs. So, people use to look at those photographs and identify what feature is there? So, that is known as photo interpretation or visual interpretation of aerial photographs.

Say, this is like a patch of land with crops in it, so this is cropland, this is like a township, so this is built up area, maybe some sort of semi urban. So, here is a pond, a water body. So, whatever is present in a photograph, identifying them visually is called visual image interpretation or photo interpretation.

Even after the advent of satellite images, people were still doing it for quite some time. Say normally, in satellite images, especially in the olden eras we will be getting one image for each band as printed maps. So, each band you will get one, one data, if it is computer based analysis, you will see an image in a big screen and identify it. So, it is still visual image interpretation, but identifying it on a screen was also done. Like just displaying the image on the screen and delineating using some sort of input device. So, when that happens, normally people will order for a true colour composite or a standard false colour composite.

So, what is true colour and standard false colour? True colour is, say sensors can take data in RGB NIR band, all these things we know. So, whenever you get a satellite image printed on sheet, we will not be getting just one band separately. For the Indian remote sensing satellites, they used to give us different bands combined together. Say red band, green band, blue band, when you want to display a colour images in some sort of display medium either on a paper or on a screen, we will mix it in terms of its corresponding colours. Say in display pattern there will be again red, green, blue colours when these 3 colours mix, you get an colour image display, that is the nature how our normal display systems works.

So, when you display a red band image correspondingly in the red colour of the display system, high DN values in red band will appear in bright red colour, low DN values and red band will appear like very light red in colour, like that. Similarly, green band from satellite data assign to green colour in display, blue band in satellite data assigned to blue colour in display.

So, such corresponding mapping between the data and your display system, we call this as true colour composite. But since blue band undergoes lot of attenuation like atmospheric scattering, normally blue may not be printed; people will replace blue with NIR band. So, satellite data, it will be red, green, NIR, in display system NIR will be mapped to red, red will be mapped to green, green will be mapped to blue.

So this particular pattern of colour is known as a false colour composite. So, the true colours which we see are not there. So, what is actually appearing red, that is not red, that is the signals in the NIR band. Similarly, what is appearing as green, it is not green, that is due to the signal in red, but we are seeing it as green. So, this kind of mix and matching or displaying some other colour for a data in some other band is known as false colour composite. So, whenever hardcopy satellite images were printed and delivered to users, normal users can order either a true colour or a false colour composite. Say people will order a false colour composite, they will have a look at it ok, there will be what is known as a light table there will make a huge tables attached with lights underneath.

So, the satellite image will be spread across that particular table, then transparent tracing sheets will be placed over the image and they will be bounded properly. And expert image interpreters will manually trace whatever different features are, by looking at the false colour composite data and by using visual interpretation clues. So, they will manually trace such features and that thing will be considered as LULC map, then it will be transformed into a proper map. So, that was how LULC map were prepared in the olden days. So, if we want to do a change detection analysis, this is the LULC map produced using this year, this is the LULC map maybe in the next 5 years, compare them and overlay them and identify what are the changes.

So, such things are done manually using what is known as photo interpretation or image interpretation. So, normally, there is a slight difference between photograph and image if you look at some of the textbooks they will define as if you use the detector itself as a storage medium, you call it as photograph. Say our film, what we used in our olden day camera that is the one which detects the incoming light, at the same time that will be used to store the image also.

When you take the film, you will develop it, so that contains actual information, you call that as photographs. In satellite image you call it as an image, it will be stored somewhere digitally, then it will be transformed to the ground and you will take separate printouts. So, there are minor difference especially some textbooks will have this difference and also it is convention to call aerial photographs and satellite images. We will not normally call satellite photographs nowadays, most of them we call as images, so that is the minor difference. So, this was done in the olden days, at present especially in the last say two decades digital classification techniques have developed.

So, digital means rather than using a hardcopy satellite images, people moved onto digital images which can be directly displayed on a computer. So, digital classification techniques emerged or developed**.** By looking at an image, we will be able to extract information using computer based analysis, using either spectral clues or spatial clues. Spectral clues means, say each particular land cover category may have one spectral reflectance pattern**.**

If you have multiband image, you can just try to extract the spectral reflectance pattern and maybe match with your ground or reference information, such thing can be done or you can manually digitize few pixels telling that, ok this is a water body, this is a built up, say maybe some 100 pixels from a big image if we classify this and then tell the computer, ok, I have identified you few pixels, then you classify the rest of the image, these are digital classification techniques which is widely used now.

So, from satellite images either by looking at it visually or by using digital classification techniques, it will be possible to get LULC information and also to do change detection.

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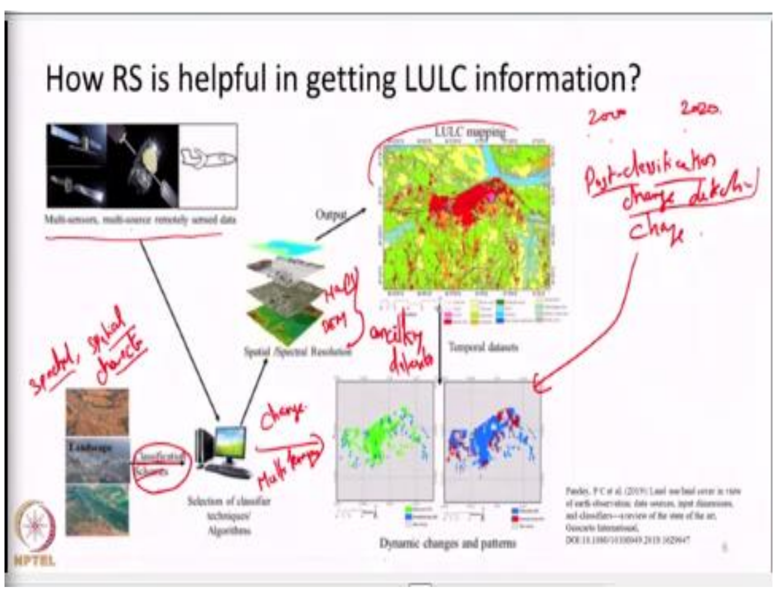

So, this is a schematic of how remote sensing is helpful in getting LULC information. So, there are plenty of different satellites, different modes of platforms are available. We have different, different landscapes each having its own spectral and spatial characteristics. So, we will normally acquire the image over the landscape, we will have images, so we will get the image downloaded, we will develop classification schemes or decision rules.

So, by combining the image and by combining the spectral and spatial characteristics of different, different landscapes, inputting them into classification schemes, we will be able to get a LULC map. So, we will use not only satellite images, we can use digital elevation models, we can use other existing maps and so on. So, these are called ancillary datasets. Let us say I have LULC map for year 2000 and now I have LULC map for year 2020. I can compare them and do temporal change analysis, this is called post classification change detection. But this need not be done always like this. And some people even do not prefer this, if our goal is to only do change detection, we can directly do from here just by comparing multitemporal images and by applying this classification schemes to those images.

So, we can either create LULC map then perform change detection analysis or directly by using multitemporal images and change detection algorithms, we can directly come up with a change map, so both of them are possible. So, there are plenty of or variety of algorithms and methods available to do land use, land cover classification. So, we will just broadly see how the different algorithms for LULC mapping can be classified, what are the different ways it can be classified? We will not be going into details of seeing those algorithms, but we will see what different classes of algorithms exist as a basic knowledge.

So, first thing is whether we are going to give any sort of inputs to the computer like a training sample to the computer, based on that we can classify the algorithm. So, whether training samples are used or not that is the first category of classification. We will display an image in the computer and then we will identify few pixels for each class, say this is water, this is built up area, this is cropland like that we will identify few pixels. And then we will ask the computer algorithm to work on the rest of the image to classify it entirely. Say there can be thousands of pixels in the image, but we will identify maybe a few tens of pixels for each class and rest of the pixels will be classified by the algorithm. Such classification procedure are called supervised classification approach, that is as humans we are supervising.

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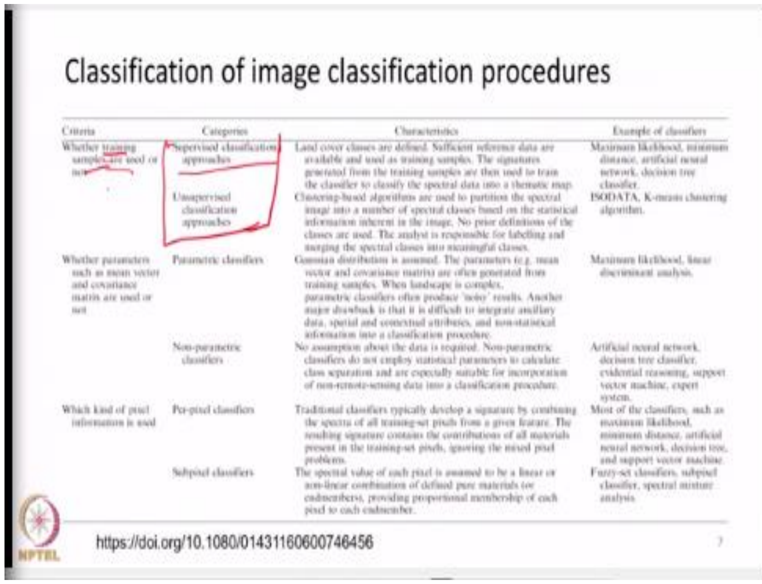

So, similar pixels should be categorized as built up by the algorithm. So, we are training or we are inputting something to the computer. Then on the other hand, sometimes we may not be knowing what is there, but we may want some preliminary information. So, we may ask the computer to identify spectrally similar features by looking at the spectral characteristics or spatial characteristics. There can be say 100 pixels comprising of cropland. So, most likely the spectral signature will be closer to each other, they will not be exactly matching, but they will be closer to each other. So, we will try to identify such pixels which have similar spectral characteristics or maybe spatial characteristics. So, identifying those pixels the computer will tell, ok these are all the groupings I can make.

Say this is one cluster of pixels, this is second cluster of pixels, it will tell us. So, what we can do is, we can have a look at such cluster of pixels and then maybe go to ground and say, ok this is one cluster, the cluster in the ground is actually a cropland. So, this entire cluster must be cropland. Doing such thing like getting the clusters as output first from the computer, then assigning actual classes to it, that procedure is called unsupervised classification. Because the computer is actually doing the clustering thing, it will not classify, it will just tell maybe the basic algorithms. Nowadays AI based algorithms with our input can function many things. But still, older classical algorithms will be telling, these are the clusters or group of pixels; it is up to us again to further define what those groups represent on the ground, this is called unsupervised classification.

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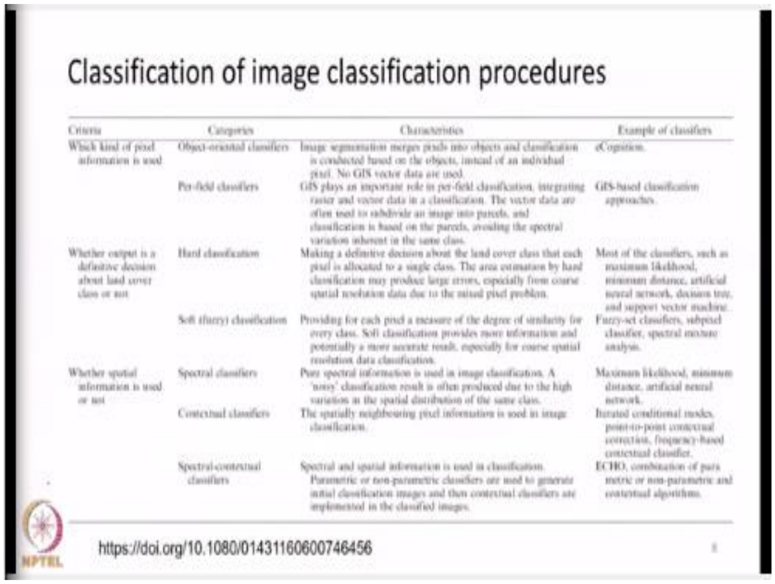

Then next major category of classifier is, whether we do 1 pixel, 1 class or sub pixel classification. That is let us say there is like a some images there with 100 meter by 100 meter pixel resolution. But, so each pixel corresponds to 100 meter by 100 meter, so there can be many different features present within that particular pixel, there can be like a small part, there can be like a building and so on.

If one pixel corresponds to only one class, say what is present their majority, if you assign that particular thing, we call it as per pixel classifier or sometimes we will be also interested to know what are all different features present within the pixel. Say, this pixel contains 50% cropland, 20%, built up area, remaining thing as water body. If we identify such sub pixel level classification that is called sub pixel classifier. There are few algorithms even to do that. Then the next major classification will be whether are we using only the spectral information or spatial information or both. So, spectral information means, we will just take an image derive the spectral characteristics of the data and just by looking at the spectral characteristics of data, we will identify what is what? So, those sorts of classifiers are spectral classifiers. But, with the advent of very high spatial resolution data, less than 5 meter spatial resolution, if you have a look at those data only by looking at the spectral reflectance curve, we may not be able to get actually what is present on the land. We may also need to have a look at the spatial information present.

But when you have a look at 2 meter data, the same building will now be occupying several pixels maybe like 10 pixel by 10 pixel or something. So, the building can be say 20 meter by 20 meters,. So, when you have a look at a medium resolution data, a land cover feature will be entirely present within the pixel. But now, it is now spread across multiple pixels, so we have a look at the spatial patterns.

So, such algorithms also developed, they are known as contextual classifiers or spatial classifiers. So, whether are we using spatial information or not in our classification, using that we can classify our algorithms as spectral classifiers or contextual classifiers or hybrid, it can use both spectral information as well as spatial information. So, these are some examples of different classification, procedures that we have.

These are just a very brief introduction to the topic, the topic is very wide like image classification, pattern identification is very wide. But we have just discussed very briefly about the different class of classifiers. So, with this we end this particular lecture.

Thank you very much.