Laboratory Practices in Earth Sciences: Landscape Mapping

Dr. Javed N Malik
Department of Earth Sciences
Indian Institute of Technology, Kanpur

Week- 03
Lecture- 11

Hello everyone. So, in the last lecture we learned how we can download different kinds of satellite data from different websites. So, we have learned how we can download the SRTM data, Cartosat-1 data and ALOS-Palsar data and how we can use this data to interpret and get more information from this data through the GIS platform. And we have also seen some basic layout of the QGIS that is a freely available software. So, today we will start with our second lab that is georeferencing and we will see how we can do the ah georeferencing ah through the QGIS as well as we will give an ah short ah description about the georeferencing through the ArcGIS. So, georeferencing is the process of assigning location to the geographical digital object within a geographical frame of reference.

So, the images which we are getting through the satellite data or sometimes the images which we are capturing through our photographic cameras. So, it is very important to assign those photographs a geographic coordinate system that means the latitude and longitude. So, what is georeferencing? Georeferencing means a non-georeference image is georeference to an existing image that that is already assigned a geographic coordinate system and with the help of that ah georeference image we can ah assign an ah non-georeference image to the geographic coordinate system that means the latitude and longitude. So, it is a process of taking a digital image that could be your ear photo, a scanned geological map or a picture of a topographic map and adding geographic information to the image.

So, that GIS platform or mapping software can place the image in its appropriate real-world location. This process is completed by selecting pixels in the digital image and assigning them geographic coordinates. So, how do we do the georeferencing with the GIS platform? So, georeferencing is accomplished by selecting a cell that is a grid with the DN values at the base image. Base image means that image has a non-geographic coordinate system and finding its corresponding location in the target image means target image means the image which does not have the geographic coordinate system with the help of projections and then computing the DN value for that point in the target image by resampling method. So, what are the projections and the resampling method and how do we ah how the projection and the resampling method work by doing the coordinate transformation that we will see in our coming slides.

So, in general there are four steps to georeference your data. The first step is selection of a base map or the image which has a known coordinate system in terms of latitude and longitude and then selection of GCPs. GCPs are the ground control point the ground control points are the ah some common point in both the images which you can easily identify in ah both the images mean the in your ah base image and you're in your target image. And with the help of this GCPs or control points you can overlap this ah this both the image means your target image on the ah your base image. And use the georeference tab in your GIS software to create the control point and connect your raster to a known position in the map and then select the transformation method.

This transformation methods are select based on the how much you want to distort your image means ah ah if your image is initially having some ah assign some coordinate system and, but it is associated with some kind of error and then you want to ah rectify the image in that case you have to you can apply a first order or second order of polynomial equations or transformation method. I will tell you what are the first order or second order polynomial equations in the next slide and then you just assign the DN values to your targeted ah image and then review or match the control points which you have chosen for both the images and the error. This error is associated based on your ah label of polynomial equations or the ah your ah the error associated while choosing the control points and at last save the georeferencing result when you are satisfied with the alignment. Now at the control points, the georeferencing process involves identifying a series of ground control points in terms of x and y coordinate that is the latitude and ah ah longitude that link location on the raster data set with location in an especially georeference data. Control points are locations that can be accurately identified on the raster data set and in real world coordinates.

Many different types of features can be used as identifiable locations such as road or stream intersections, the mouth of a stream, rock outcrop, the end of a jetty of land, the corner of an established field, street corner or intersection of two head rows. So, these are some of the ah points which you can use while choosing your ground control points. So, in this image you can see this is your ground control points, this red circle this red circle is your ah it is a corner of a two plot and you can easily identify this corner in your target image and your base image. So, you can choose this corner as your ground control point. Similarly, here the second ground control point is a house or and if you are able to identify this house in both the images.

So, you can choose this house as your ground control point. Similarly, in the second image you can see this is the corner of a house or a building and this point you can choose as an ah your ground control point. So, similarly you can also choose an intersection of a road where two roads are crossing each other. Suppose this is one road and another road is

passing from here. So, this intersection point you can choose as your ground control point.

So, these are some of the factors. So, how you can choose your ground control point and the basic concept is that you would easily be able to identify this ground control point in your base image and your target image. So, the transforming ah transforming the raster image. So, when you are ah georeferencing your target image with the help of your ah base image that is already georeferenced. So, there is a coordinate transformation from the ah base image to the target image.

So, this coordinate transformation is done through some polynomial equations. This polynomial equation is assigned based on the ah based on the order of distortion you are doing while transforming the coordinate system from ah target image to ah from base image to target image. So, the polynomial transformation uses a polynomial build on the control point and at least square fitting algorithm. The lower order polynomial tends to give a random type of error while the higher order polynomial tends to give an extrapolation error. That means, that if you want to simply rotate or displace your image slightly.

So, in that case you have to just apply the lower order polynomial equations. For example, the zero order polynomial equations are the first order polynomial equations. And if your image is distorting while ah doing the coordinate transformation in that case you have to apply the higher order polynomial equations to do the coordinate transformation ah and georeferencing. The number of non-correlated control points required for this method must be 1 for zero order polynomial equations and 3 for a first order polynomial equation or affine coordinate transformation. You have to choose the 6-control point for a second order polynomial equation and at least 10 ground control points for a third order polynomial equation.

So, keep in mind that the higher order polynomial equations you want to apply you need to add a more ah ground control point to do the georeferencing. A zero-order polynomial is used to shift your data. This is commonly used when your data is already georeferenced, but a small shift will better line up your data. Only one control point is required to perform a zero-order polynomial shift. Here in this image you can see this is suppose this is your original data and you just want to slightly modify or shift your data in that case you can apply the first order or the affine polynomial equations.

And if you want to know if your data is associated with some higher order of distortion in that case you have to apply the higher order of polynomial equations. In this case you have to apply the second order polynomial equations and for the more distortion data you have to apply the higher order polynomial polynomial equation that might be the third order polynomial equations. So, here use a first order or affine transformation to shift scale and

rotate a raster data set. This generally results in a straight line on the raster data set map as a straight line in the barbed raster data set. The higher the transformation order the more complex the distortion that can be corrected.

The second method is after coordinate transformation you have to assign the DN values to your ah your ah pixels in the target image. So, this is done through the re-sampling or interpolation method. So, how ah this is this can be done here we can see. So, three types of resampling methods are used to assign the DN values to a pixel. So, first is your nearest neighbor.

So, what happens when suppose this is your this is your target this is your target image and this is your this is your base image. So, it is associated with some ah DEM ah pixels and it is associated with some DN values and you have just co-registered with the coordinate system. Now you want to assign the DN values. So, what will happen during the ah with the help of polynomial equations you have registered this image and or overlap both these image images. So, now, if you suppose you want to assign this grid or this pixel your DN values.

So, in the nearest neighbor method what will happen when this pixel will get the DN values the targeted image pixel will get the DN values from the base image from its whichever pixel is nearest to this pixel when you overlap both these images through the polynomial equations. So, this pixel or this grid will get the DN values from its nearest grid or pixel. So, that is your nearest neighbor the point in the new grid simply acquires the DN values of that point in the older grid or the or the base image which lie closest to it and the second method of second resampling method is your bilinear interpolation. In the bilinear interpolation the pixel is simply getting the DN values from its 4 pixels which are closest to it. That means, suppose this is your pixel or grid of the target image.

So, this pixel or grid will get the DN values from the surrounding 4 pixels or 4 grids. So, suppose these are the 4 grids from your base image and this pixel or grid will get the DN values from these 4 pixels. So, this method is called the bilinear interpolation method and in the cubic convolution when your target image pixel is getting DN values from the surrounding 16 pixels or grid. So, in that case you this method is called your cubic convolutions. So, after doing the coordinate transformation and assigning DN values you have to simply look for the root mean square error.

So, that is the error which is associated with the georeferencing method or your polynomial equations or the choosing the ground control point. So, you have to look for it. When the general formula is derived and applied to the control point a measure of residual error is written. The error is the difference between where the point ended up as opposed to the

specified locations. The total error is computed by taking the root mean square that is the sum of all the residuals to compute the rms error.

This value describes how consistent the transformation is between the different control points. When the error is particularly large you can remove the remove and add a control point to adjust the error. So, now, we will see how we can do the georeferencing with the help of ArcGIS. Here I will explain it how we can georeferenced toposheet on the ArcGIS, but we will give a demo to georeferenced toposheet on the QGIS because as in our last lectures we have installed the QGIS and we have also given a demo on the QGIS. So, we will show you how we can do the georeferencing on a QGIS as well as the ArcGIS. So, ArcGIS as in our last lecture I described is also a GIS platform where you can do all kinds of mappings.

So, when you open ArcGIS you can see that this type of window will open here. Similarly, here you can see the file edit insert selection tool window. It is a similar kind of window which you have looked at in your QGIS and here you have to open your data. You will simply see a plus sign with clicking this plus sign you can add your data. So, here we will show you how we can georeferencing topographic maps. So, first we have to open the toposheet with the help of this plus sign and here in this layer option you can see all the layers or the files which you have opened. So, here we have opened a toposheet. The toposheet name is L3479 and it is in a jpeg format.

So, here you can see in this layer this image is opened and you have to do the georeferencing you have to georeference this toposheet. So, first thing you have to keep in mind then when you are opening an image first you have to check whether this image is georeferenced or not that you can easily see here this in this section on the ArcGIS platform here you will see there is some values are written that is in negative or the unit section it is written the unknown unit. That means, this image is not georeferenced or this image is not assigned any coordinate any coordinating form of latitude and longitude. So, in the second step to georeference a toposheet first you have to zoom your toposheet at the corner side. When you zoom your toposheet you can see that your longitude and your latitude are written on the toposheet. So, for example, in this toposheet the upper left corner of this toposheet is 74 degrees and 30 minutes and the latitude is 90-degree 0 minutes.

So, to do the georeferencing you have to go to the first you have to go to the view section and in this view section in the panel option you have to first enable the georeferencing. Here you can see this is the georeferencing panel and if this georeferencing panel is not enabled then you have to go to the view and then from there you can enable the georeferencing option. Once this georeferencing option is enabled you can see this georeferencing panel over here and here you can see that your open map is also you can

see here this is your map which you can georeference with the help of your GIS, ArcGIS. To do the georeferencing first you have to select the control point. To add the control point you have to just go to this option this option will direct you to the add the control point.

When you click this option and this a pop up will come up they enter coordinates and when you will this coordinate is for this point. So, when you click this point and you enter this point in x and y that means, latitude and longitude. When you enter latitude and longitude in x and y and you click ok. So, this will mark you on your map and similarly you will mark on your map. And similarly, you have to mark all the four corners by scrolling your mouse or zoom of that particular section and you have to mark all these four corners and you have to add the four-control points.

With the help of these four control points you will be able to get the GCPs. And you will see this to analyze or review your GCPs or the associated error you can see you can click over here and this will open a table and, on the table, you can see or review all your points. Here you can see this is your point which you have marked based on your toposheet. So, here you can see this is four points and is x y and this is your residual. So, the residual is your associated error with that individual control point.

For example, for the first point your associated error is 14.9 and then 14.9, 14.9 this is your associated error for all the four points. And at the bottom corner you can see this is your total associated error, the RMS.

And here you can see for this toposheet here we have chosen the first order polynomial equation. So, as I already described, when your total distortion is minimum in that case you can apply the low order polynomial equations. And if the error is higher than in that case you have to apply the higher order polynomial equation. So, after selecting all the points or all the GCPs you can directly go to the georeferencing option and you can click over there. So, you will get some of more options here you can see the update georeferencing rectify flip or rotate transformation auto adjust update display delete control point and reset transformation.

So, these are the options where you can change the transformation if you want to apply the higher order polynomial equations. You can delete your control point if you are getting the higher amount of RMS for a particular point. You can delete that point with this option and you can again add a new control point with a minimum error. And after doing all these practices and after selecting all the ground control points you can just click the update georeferencing and this will georeference your error and this will georeference your image. So, while your image is georeferenced now you have to save your georeference image to save you just go to the save as option and here you can see few options are given the

resampling method. So, the resampling as I already describe you is assigning the DN values.

So, what kind of resampling method is suitable for your particular data that you can shuffle or you can check through this down arrow where you will see the nearest neighbor the bilinear and your cubic convolution. So, you can shuffle these options and you can see which one is giving you more accurate georeference data that you can choose for your data. And then there are few options given the file name and image format in which format you want to get your georeference data that you can choose and finally, you can save your data and you can open it when you open your data in your GIS platform. So, this image or your file is now georeferenced how you would know that your image is georeferenced here you can see at the down corner at the right down side of your screen you will see this is your latitude and longitude is written over here.

So, now, this image is georeferenced. So, now, we will move to the QGIS software and over there we will give you a demo on how we will georeference a toposheet first with the help of the QGIS and then we will also give you a demo on the a toposheet. So, this is the toposheet. So, this is the image which is not georeferenced with the help of the base map. So, there is two method one is your in first method I have just described that how you can georeference a toposheet where the latitude and longitude is already given and another method is when your image is there is no latitude and longitude mentioned over on your image in that case you have to use a base map that is already georeferenced and how you will georeference your target image with the help of that base image. So, I will give you both the examples with the help of QGIS.

So, in the next lecture we will see how we can georeference the images on the QGIS platform. Thank you.