**Laboratory Practices in Earth Sciences: Landscape Mapping**

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

**Week- 02**
**Lecture- 07**

Welcome back. So, today we are going to talk about line of flight and this line of flight I have explained to you earlier also. But the add-on part here is we will be talking about the relief displacement and mainly using the aerial photograph or you can also say that if you have collected the data using UAV you can get the height of the object. So, that is the main point here. So, again briefly or we can say quickly we will look at the line of flight how we are going to identify and of course, that is important that helps us in knowing the orientation of the flight path as well as the photographs which have been taken during the flight. So, line of flight mainly as we have already discussed that the overlap is most important for having the stereo photographs and that helps us in viewing the terrain in three dimensions.

So, the overlap of the photographs will be 60 percent and the side path will have an overlap of 25 to 30 percent. So, overlap 60 percent or 70 percent you will have in the side way. So, this is what has been explained here that you have when you are flying in one direction for example, this is the flight line of flight. So, the flight is going like this and it will collect the photographs and if it goes back here.

So, this will have 60 percent overlap and whereas, it is going sideways this is another path of this will have the 60 percent overlap this is your 60 percent this is your 60 percent whereas this one will have your overlap of 25 to 30 percent. So, even in this you can have like an overlap of 70 percent also, but anyway that depends on what but minimum at least you should have 60 percent of overlap. Now as per our wish that the flights or the aircraft should not have any sort of a deviation that is not possible because that will always happen because there is a wind action and due to that you will see some drift, but nowadays the softwares is available that will help us in correcting parts also. So, stereo coat photography is what I discussed in the previous lectures. So, mostly what we do is that this is what is shown here with another illustration that you have the 60 percent of overlap along the line of flight and sideways you have 20 or 40 percent of overlap.

So, what exactly in the photograph when it is collected tells us that we have also discussed briefly in a previous lecture about the principal point and the conjugate principal point. So, if you take this one photograph for example, this one is the first one. So, you are having this photograph over here and this is your overlap with another photograph if you take this as a center here and this is a center here. So, this will be an overlap of 60 percent and you

have no this will be having the overlap of 60 percent over here. So, what exactly we are looking at is the if we our flight is almost like flying perpendicular to the surface that is ortho photographs it is collecting then the this will be your principal point of the first photograph that is you can also say that if it is vertical exactly vertical then this will be your Nadir point and the second photograph principal point will be this and respectively you will have the conjugate principal points.

So, this usually is helpful when the photographs have been collected and you want to do the mosaicing and also you want to find the line of flight. So, for example, this is another illustration which shows how the photographs are collected and mostly we consider and we want that this photograph should be collected with an almost vertical angle. So, this is exactly what we have discussed in the previous slide also. Now, let us look at the orientation of the photographs. So, what we do is that we try to take two photographs which are taken during the mission and these photographs have a particular number that I also explained in the previous lecture when we were talking about different aerial photographs.

So, there are marks which are available and this is what we call the footage mark and you will have if you are numbering these photographs then it will be printed on the hard copy what you have in here. So, this photograph number is 2A 32 and then another one is 31. So, you have some common features here because you have 60 percent of overlap. So, next slide we will see how we are going to put photographs and plot the principal point and then conjugate principal point and connect all those and transfer the principal point and conjugate points on either photograph and then try to find out the line of light. So, you see some common features here with the landscape for example, you have a channel here and then a similar channel is over here you have and there is some landform over here which you can see and, in this photograph,, you have this one here.

So, this is how you can also easily make out that there is an overlap in the photograph. Now, orientation of the photograph for locating the principal point partially we have discussed this, but again we will see that if we have the fiducial marks which are available over here then we will take those fiducial points if not then we will connect this diagonically diagonally and diagonal points the intersection will be your principal point and then subsequently you will mark the conjugate principal point. So, determination of the line of light if you take the same photographs has been taken here. So, you have a slight change because it has been marked here. So, this photograph is slightly up here compared to this one, but you have fiducial marks.

So, you have to connect the fiducial marks and then obtain your principal point. So, this will be a principal point of the first photograph and then similarly marking P P that is the

principal point on the right photograph that was in the left and so this again you have done this. So, you will get a principal point here in the second photograph. Now, the time is to plot the conjugate principal point. So, the best way is that you because you have this principal point over here and there is some sort of an outline of the landscape over here which probably goes here.

If you see in this photograph it goes somewhere here. If I mark it properly here then you will find this like this. So, this is also like in another photograph. So, it has been marked somewhere over here actually. So, this is the principal point of the photograph number 32 and so you can make the conjugate principal point.

So, this will become your mark here, this will be your conjugate principal point. Similarly, this will become a conjugate principal point here and similarly you will need to transfer and again this portion of this landform has been seen here. So, if you can see this one here, it has been seen here. So, you transfer this over here and that will give you the relative conjugate principal point. Now, having these four points will help you in identifying the line of light.

So, you need to connect this. So, you connect this to a line of light. Now, if you have the complete understanding of the line of light that there is slight deviation over here in terms of the photograph. So, when you mosaic it you will have an easier way or it will be easier for you to identify the way and then you can have the complete 3D view. And if you are not aware of that then you will usually try to match this edge and this edge to view the 3D, but that will not be possible to see.

So, lines of light can be done like this. Now, another topic which we were talking about is your relief displacement and that there are methods to do that, but the method which we are trying to explain is also in Robostone and mostly it has been followed. So, distortion in aerial photos may also be used in the aerial photos. So, it may be due to the fact that as I said, it is not always that we will have a very stable flight. It may have some drift and all that.

So, you have what we call the yaw that is your rotation with respect to the center axis. So, this is your yaw that the center axis is over here. So, there will be slight rotation and that is clockwise or counter clockwise. Then you have pitch and pitch is along this plane actually pitch is along this plane. So, this is the plane along which you will see the pitch and that is your up and down movement along the vertical axis.

So, yaw is rotation along this plane that is your horizontal plane you are having and you have an axis over here and then third one is roll. So, rotation of the aircraft from nose to

tail and that will be over here along this plane. So, these are three components which will be experienced during any flight and that will result in the distortion. So, relief displacement over an aerial photograph conventional aerial photographs will have distortion caused by poor camera optics . These are the reasons for tilting the camera. So, if your camera is slightly tilted it is not exactly vertical then also you will have distortion.

So, that has to be very much taken care of. So, nowadays we have like automated aircrafts which have the gimbal. So, that will automatically try to make the camera. So, if the camera is hanging like on the gimbal. So, it will keep on having the vertical as much as vertical it can.

Even if the aircraft is having the yaw or pitch or roll anything is happening there. So, that will be taken care of, but if you are having the fixed camera not on the gimbal then you will have difficulties. Then this cannot be that the third point cannot be taken care of there will be tilting of the terrain that is your topography. So, topography will give you some distortion. So, this is your tilt part.

Now distance from the central perspective and that usually we try to take that the central point is your nadir point. So, there will be slight distortion from your center that is the nadir point and if you are moving away from the center. So, that will be there. Vertical relief again will give you the relief displacement. So, the second and third point will give you the tilt whereas, the third and the fourth point will give you the relief displacement.

Hence the photograph scale will not be uniform throughout, but as I said that nowadays the softwares is available to nullify all this, but then also we need to be careful and try to look at the scale of what we are getting from the ground. So, usually what we do is that we try to put additional data which is collected from the ground control points. So, the relief displacement cause is the object and or the terrain with vertical relief are not image from the central perspective that is your nadir. So, that will result in the object appearing to lean outward from the center. When the original object is almost vertical because usually we do that.

For example, there is a building here. So, the original is like this, but you will find that it has been seen as something like that. So, these are the issues which one can face. So, the relevance is that the correct planimetric position is not represented on the map. This is what we are going to get if we are having the tilt in the photograph or we are having the terrain not flat terrain; it is an inclined terrain and if you are imaging away from the center that will happen.

So, for example, these are three with two photographs which have been given. So, bends

in the road as shown in 3D view or with topographic relief. Straight road as shown in 2D view or no relief. So, you will find this issue in the photographs. And if you want to quickly look at this then you can go to the Google earth platform and try to see sometime you will find that the roads are just climbing over the terrain and all that.

They are not very straight, but in reality they are straight. So, why is relief displacement observed on the aerial photograph due to variable height of the objects. So, this is one issue which you will face. So, in stereoscopy usually what we do is that we have the two different views of the terrain with two eyes. Not this, but the same overlap area we can see, but we are not viewing this area with this eye, that is you view the photograph left photograph with the left eye and right photograph with the right eye that you do.

So, this is basically how we are viewing the stereo photographs. So, the relief displacement of an object in the photo is basically due to a change in the point of observation and this is termed as parallax and we also termed this as a stereographic parallax. So, stereographic parallax is because of taking photographs of the same object, but from different points of observation. So, for example, you are having a terrain here topography and this is your datum and this is your right and left photo what you are viewing is over here. So, you are having the different height of the overall terrain which has been shown as point A and point B.

So, if you are viewing this with the different side at the same the the different eyes with the this is the same area and then similarly you are trying to view. So, overall you are trying to view this whole terrain which is having different heights. So, the observation point changes. So, due to change in the observation point you will have what you see is the relief displacement. So, now the best way one can do is that if you have the principle point or on the photograph considering the photograph has been taken vertically around that and this will be your also nadir this is your nadir point.

So, as you move away from the center you will see a sort of a distortion not distortion, but you will see the object and be inclined. Now you have this you can see from the center from the photograph that this is the building top and this is the base of the building over here and this height which is not the true height which you see here. So, what best you can do is that you take the distance from the principal point to the top that will help and that we will see in the next slide how this is going to help us. And then also measure this distance over here in the photograph. And other parameters which are required or information which are required is the height of the flying height and all that that you will be getting from the aircraft which we are flying.

So, just keep in mind that you need to have this small r and d here which is the height of

the building or the distance of over here from the top and base and the distance from the principal point of the photograph. So, object height can be obtained as you can have the to calculate the flight altitude or flight height h you can obtain the multiple like multiplying by. So, this is your representative fact fraction which you can have from the topo maps that is the scale or the based on the area that is exactly the portion of the map that has been represented on ground or the photograph on the ground. So, if you are having this distance for example, from this point to this point then you can have this information and what is the ratio of this has been represented. For example, this is like 10 meters in the actual ground on actual ground, but what is the distance you are able to see?

So, that will give you the r f. So, you can have you know the focal length you will be able to get from the camera and that will give you the height of the height flight height. So, from photographs one can obtain the height of the object which is demarcated or denoted as small h and if you have the d and r and this is already available from this information. Then you can easily calculate the height of an object. So, where small h is the object height, d is the length of the object from the base of the photograph or you can say the principal point and r is the distance from the now this is the. So, that this is the distance of the that is your length of this part that is the height of the building here and r is the distance from the p p and h as we have discussed here that you will get from this formula.

So, if you have to measure the height of like this building which is actually a b. So, how are you going to get it? So, let us see that. So, if you are having the datum here and this is the object height. So, we have negatives here, we have positives here.

So, on the positive side if you say this is a b then you will see that a b is the same there, but a negative it will be inverted. So, this is your exposure center. So, and the p p is p p on the negative that is a principal point and similar principal point here on the positive and on the ground that will be your nadir also. So, this will be your focal length which is known from the the camera and the height of the object a b over here can be represented or will be seen on the positive and negative here which will be b a because it will be b dash and b a dash that is your inverted one and here it will be as it is that is a b. And we have the height we can calculate from the photograph and then we have what is the relief displacement.

So, the r is the as we have seen in the previous one. So, this is the distance which you will measure on the photograph and then you will have the r from the center or you can say the from the principal point that will be your r. So, you will get this, you will have this one and you can calculate H that you can do. So, basically the representation is given as the equation is H by H is equal to D by r.

So, this is what you are having. So, H divided by C H divided by C H is equal to D by r.

So, this is what you are getting smaller H that is the height and the flying height divided by and then this you are having the from the photographs you can get. So, for calculating H you can have this expression. So, suppose the r from the central line or the principal point is 2.

2 inches on the photograph and D is 0.129 height of the flight from datum in feet it is 2978.5 then the height of the object will be this one. So, that you can calculate easily. So, this exercise also we will try to give you and we will what the data we have collected with using UAV.

So, that you can do. So, this is the same example which has been given for the tank here which you can see clearly over here. So, if you are having the flying height you are having the radial distance not what we are calling r from the P P and then you have calculated the D over here with this distance. So, you have D here and that will give you the clear-cut height. So, that is how you can calculate it. So, with this we will end here and we will continue with more details on the landform mapping in the next lecture. Thank you so much.