Forest Biometry
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Lecture - 25
Photogrammetry

[FL]. Today we will have a look at the topic called photogrammetry. So, what is photogrammetry? If you again broke it into it is word roots.

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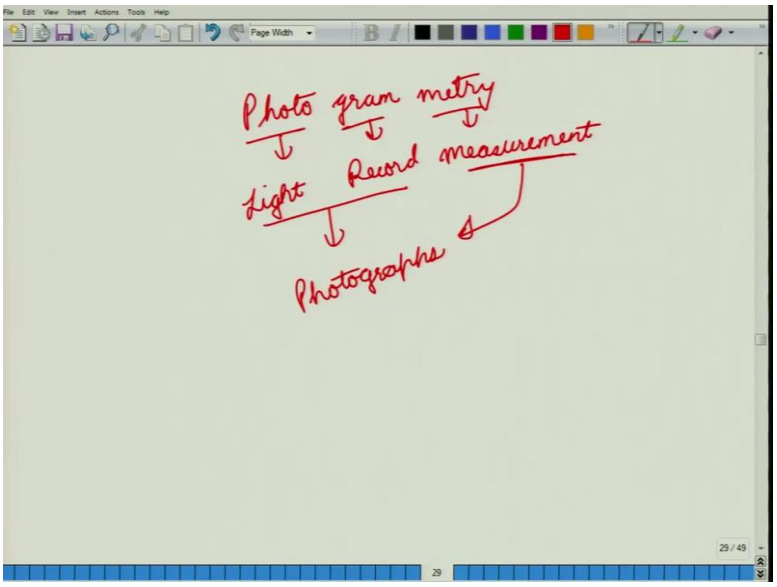

We have photo gram metry. Photo means light. Gram is a record. Metry is measurement. So, we are trying to take measurements out of light records. A water light records light records are nothing else, but photographs. So, we are taking measurements out of photographs and this science is known as photogrammetry.

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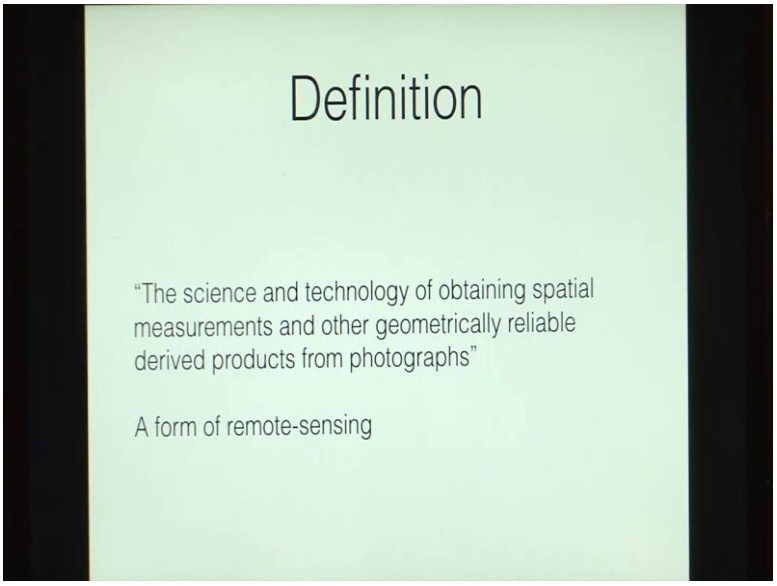

So, if you move to the slide back again this is the definition of photogrammetry. It is the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs. So, it is the science and technology. Science it comes from the latin word syntia which means to know.

So, science means knowledge. Technology is the application of science. So, it is the application of knowledge. So, it is the science and technology of obtaining or getting spatial measurements. Spatial measurements mean measurements over space. And other geometrically reliable derived products. So, we not only take direct measurements, but we can also make some other derived products from photographs. And it is a form of remote sensing. Now what do we mean by remote sensing? Remote means at a distance and sensing means to get some information out off.

So, remote sensing is the technologies that permit is you to get information about your target from a distance. For instance if you have a glass here, and if I go towards this glass and I touch it. So, this is not remote sensing because I am touching it with my hand. So, this is a physical contact, but when I have this glass at a distance and when I am seeing this glass. So, I am taking information in the form of light rays that are coming out from this glass. So, they might be coming from the light sources they get reflected from this glass and then they are coming back to my eyes. So, when I am using that information to get to get knowledge about this glass I am using a technique of remote sensing.

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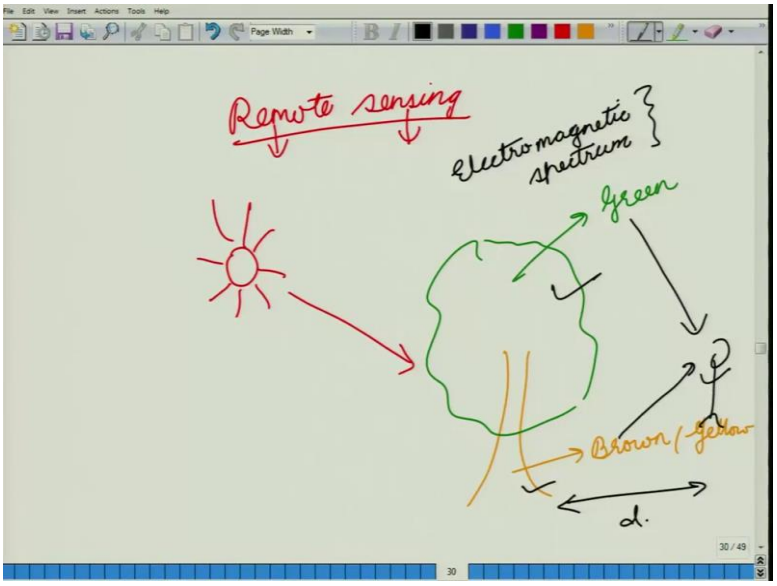

So, photogrammetry is also a form of remote sensing. So, how does remote sensing work? So, remote means at a distance in sensing is to get the knowledge. So, remote sensing deploys electromagnetic radiation. So, for instance if you have the sun. It is giving out rays of light and suppose we have a tree here let us use our conventional colours. So, we have a tree here. So, the canopy of the tree is going to interact with the sunlight.

And it is going to reflect green colour whereas, the stems are going to interact with that light and give out see brown colour brown or yellow brown colour. And we have an observer who is standing somewhere and is able to see this green colour as well as a brown colour. So, he is using these electromagnetic electromagnetics spectrum to get some knowledge about this tree that is it is canopy is very different from it is stem.

So, this is a knowledge that he is getting out of these electromagnetic radiations, while he is standing at a distance from the tree he. So, he is not in physical contact with the tree.

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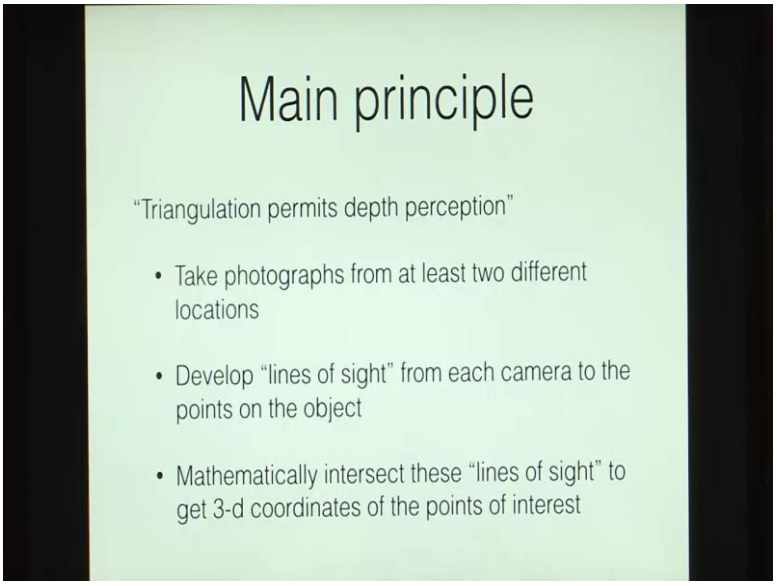

So, that is remote sensing. So, what is the main principle behind photogrammetry? So, if we went back to the slides now.

The main principle is that triangulation permit is depth perception. Now what does triangulation mean and what how does it permit us to perceive depth. So, suppose this is an individual and we have 2 eyes.

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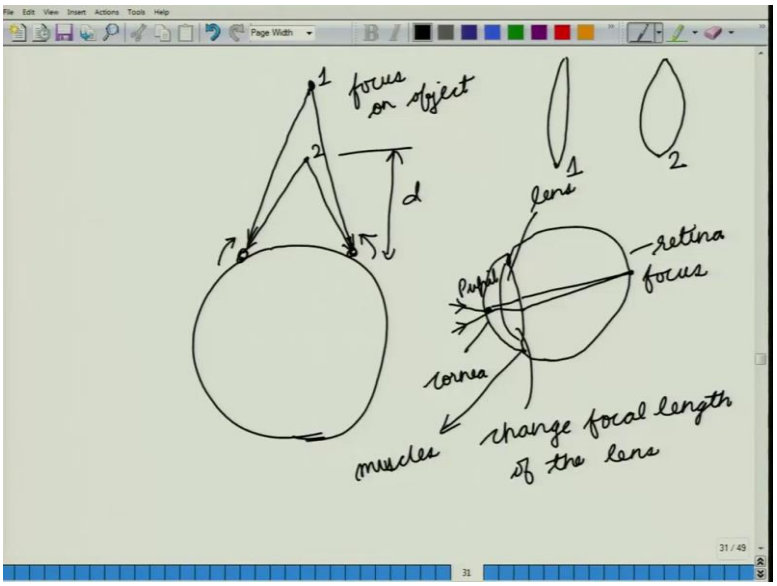

Now, if we have some object here. So, the left eye and the right eye both are getting information about this object.

Now, suppose this object were at a at a greater depth. Then the angle that has been subtended by the rays of light coming from the object are different from the angle. So, the angle subtended at position one is different as than the angle subtended position 2. The observer might also be moving his eyes. So, as to focus on the object. So, the angles are different the eyes have to be moved to focus on the object and then inside your eyes. So, if we drew the structure of eyes. So, in the front we have our cornea, then there is a pupil that is a small hole that permit is light to get inside then we have lens and then we have retina at the back.

So, any light that comes inside the ice comes from the pupil. Then it interacts with the lens and is then focused on the retina, now to permit that these rays be sharply focused on the retina. You need to change the focal length of the lens which is done through these muscles colsileria muscles.

So now if you wanted to focus at this object one which is at a greater distance the lens of your eyes would be would be more flatter as compared to the position in 2. So, for instance in case of position one if your lenses like this in position 2 your lens would be 4 bulging. So, this is position one this is position 2 which is being done by these muscles.

So, the activity of the muscles the amount of a of stretching that we have to do inside these muscles would also give you a signal of what is the depth of this object d from u. So, this is called depth perception. Now triangulation permit is depth perception it means that if you are taking a photograph of an object; so if you have an object here and if you take a photograph from 2 locations.

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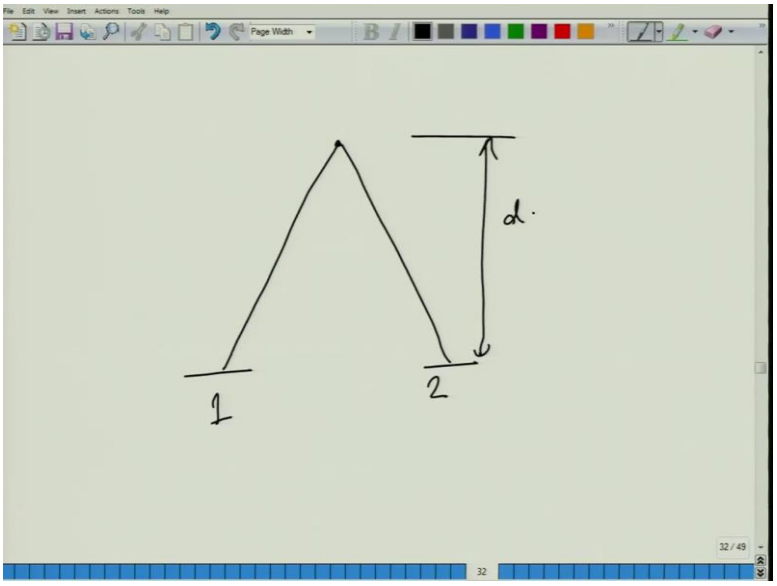

So, in the first location you have the ray coming here and the second location we have the ray coming here.

So, both these photographs one and 2 can be utilised to get the distance d of this object from the photographic plane. So now, coming back to the slides. The main principle behind photogrammetry is that triangulation permit is depth perception. So, we take photographs from at least 2 different locations for the same object. Then we developed lines of site from each camera to the points on the object. And then we mathematically intersect these lines of site to get 3 dimensional coordinates of the point of interest, to show it more graphically.

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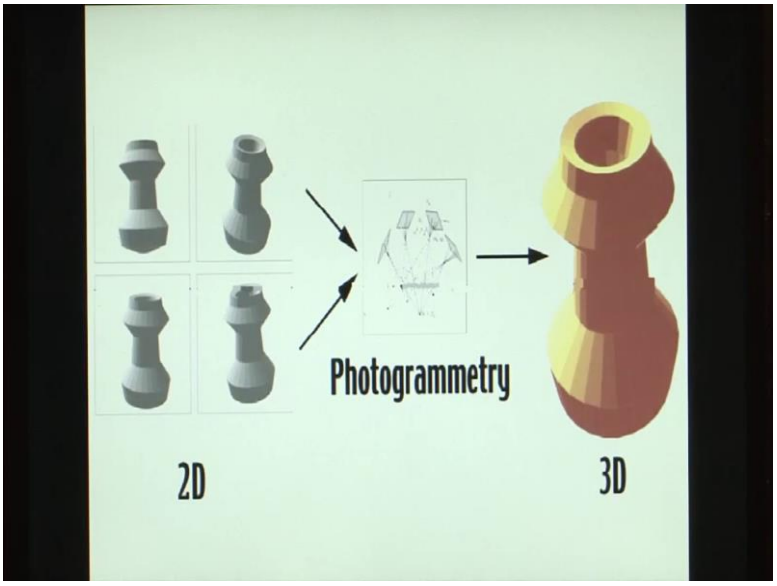

So, suppose you have an object in the shape of this mole. So, you can take it is photographs from different locations, and then by using photogrammetry you can get a 3 dimensional view of this object.

Now, there are 2 applications of photogrammetry.

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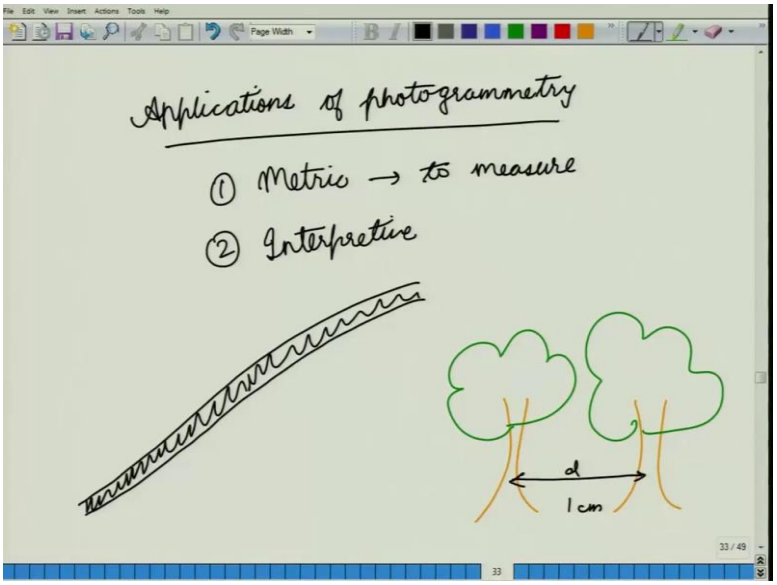

So, if you looked at the applications of photogrammetry they would be 2. One is called a metric application metric again means to measure. So, for instance if in a photograph you saw 2 trees and just from these photographs you want to know the actual d the actual

distance between both of these trees. So, for instance in your photograph this distance might look as one centimetre, but how much is that distance actually out there in the field if you wanted to measure that that would be called a metric application.

The second application is called the interpretive application. What do we mean by interpretive application? Suppose we saw these 2 parallel lines that have black colour in between these. So, does this thing on a photograph does this represent a road does it represent a tower how do we get to know about that, or is it something else. So, that would be called an interpretive application.

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So, for instance if we looked at the image now by looking at this image. So, we know that it is the canopy as seen from bottom of the forest, but when we say that this is canopy it actually represents just black and white spots on a picture, but we know that this is a canopy. So, that is the interpretive application, but if you wanted to know how much is the canopy cover if you wanted to measure that from this photograph that would be called a metric application.

Now, to do the science of photogrammetry the first thing that you need is to take good photographs.

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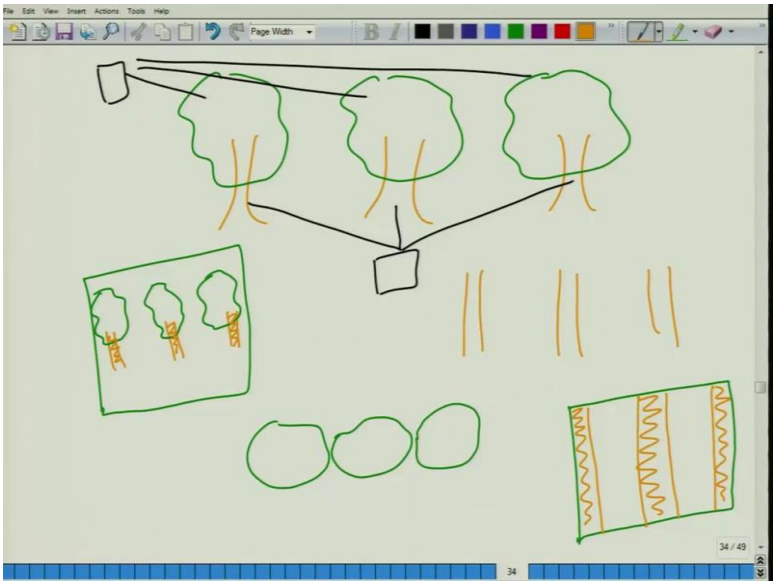

So, what are the consideration, that we need to keep in mind while taking good photographs. One is the field of view by a field of view we mean that suppose inside a forest what do you want to show in the image, if we took a photograph from the front we would be seeing these boles if you suppose we took the photograph from this point. So, we will be seeing these 3 boles whereas, if we took a photograph from the top. Then what would what will be seeing are these 3 canopies that are maybe touching each other. So, these would be giving us different views.

Now, the field of view that we are getting depends on the focal length and the angle why because we have seen how angle varies, but how does focal length vary. So, for instance if this is our photograph if you took one lens you would be able to see these 3 pick trees together. That is in the first case when we are using a wide angle lens, but suppose if we went for a lens with a with the larger focal length what we would be seeing in that case would be just these 3 boles that are highly magnified.

So, this is this is permitted as to zoom into such a level, that now it is top and bottom portions have been cut from the picture we are only able to see the middle portion and that middle portion is showing us these 3 steps. So, the field of view depends on the focal length and on the angle.

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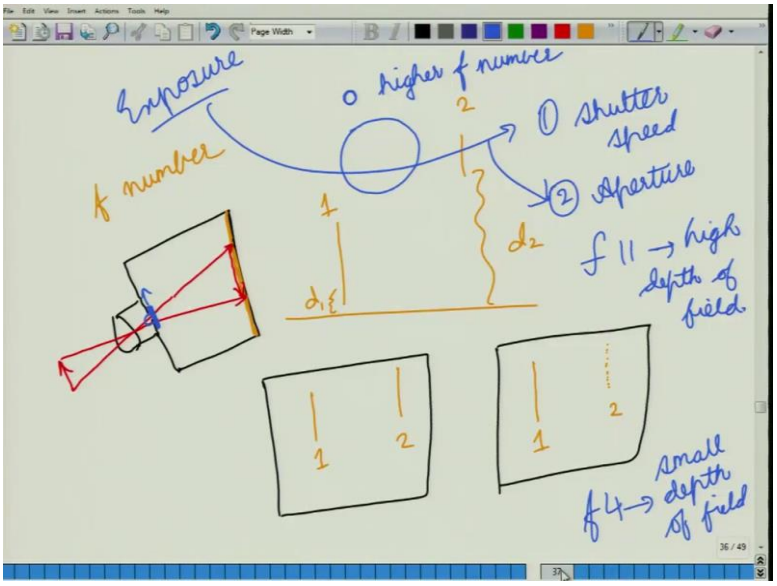

The second thing that we need to keep in mind while taking a good picture is the focus. So, for instance if we are taking the picture of a tree we could for instance focus on a leaf. So, in which case our photograph will show us the leaf or else we could focus on a portion of the stem in which we might be able to see the corrugation that are there in the stem.

Now, focus also determines the depth of field. So, depth of field means that suppose you have 2 objects. So, you have object 1 and you have object 2. So, object one is at a distance of d 1 object 2 is at a distance of d 2. Now when we take the photograph, we might have 2 situations. So, in one situation you are able to get d 1 and the objects one and 2 both in the picture and both are well focused. On the other hand we could also be having a situation in which in the photograph your object one looks very much in focus, but object 2 is out of focus. Now this thing is determined by the f number, f number of the lengths. So, what do we mean by f number? F number denotes the aperture of the lens.

So, if we considered a camera. So, a camera is very similar to r I. So, your camera would be having a lens in front then it has a shatter. And then it has a photographic film or a plate or these days at the back. So, if you have any object in front of this camera this object would be subtending rays like this and forming an image on the film or on the sensors.

Now, when we want to take a picture. So, we do not expose our film continuously to the object. What you do is we have a shutter right behind this hole. So, when the shutter is covering the hole these light rays are not able to reach there, but then when we take the picture the shutter moves for a very short period of time it exposes our film to the object to the to the rays of light coming from the object which then helps it to take the photograph.

So, when we do this there are 2 things that we need to keep in mind because we want a picture that is properly exposed. So, that is it must the amount of light that is interacting with our surface it should not be very large in which case the whole image would look washed out in white colours. It should not be very less in which case we would be having a very dark coloured image. So, we need a proper exposure.

Now, the exposure is determined by 2 things. One it is determined by the shutter speed that is how much time do we allow this hole to be opened that is the first thing. And the second thing is called the aperture. Aperture is what is the size of the hole. So, if we had a very small hole that is giving us very less amount of light we would want to expose our film for a larger duration of time.

On the other hand if we had a bigger hole that is permitting lots of light to come in we would like to have a very small shutter speed. Now another way in which this shutter the size of the aperture affects the photograph is that when we have this very small aperture that is represented by a higher f number. So, a higher f number say f 11 it would give you a high depth of field. What that means, is that objects that are close to our camera and objects that are far away from the camera both will be there in the focus. So, the depth of field or the depth of focus is very large.

On the other hand a larger aperture say an f 4 aperture. So, this varies inversely as the size of the aperture. So, if the size of the aperture is large we have a smaller f number if the size of the aperture is less we have a larger f number. So, in the case of an f 4. So, f 4 would show us a very large size aperture that this would give us a small depth of field.

So, in the case of a small depth of field if you focus at the object that is closer to us the object that is far away would appear out of focus if you focus at the object that is far away the object in front of us would look out of focus. So, this is what the focus means. Then the next thing that we need to consider while taking a good photograph is the

exposure. Exposure again refers to the shutter speed in the aperture and we need to take photographs that are neither very bright nor are very dark.

So, if you want to take photographs for the case of photogrammetry, we need to use something that is known as metric cameras. Now what are metric cameras? If you look at the slide now. So, metric cameras are the cameras that have stable and precisely known internal geometries, So that is if we use a metric camera we know exactly how much is the distance of the film from the lens how much is the distance of the lens from the hole and so on.

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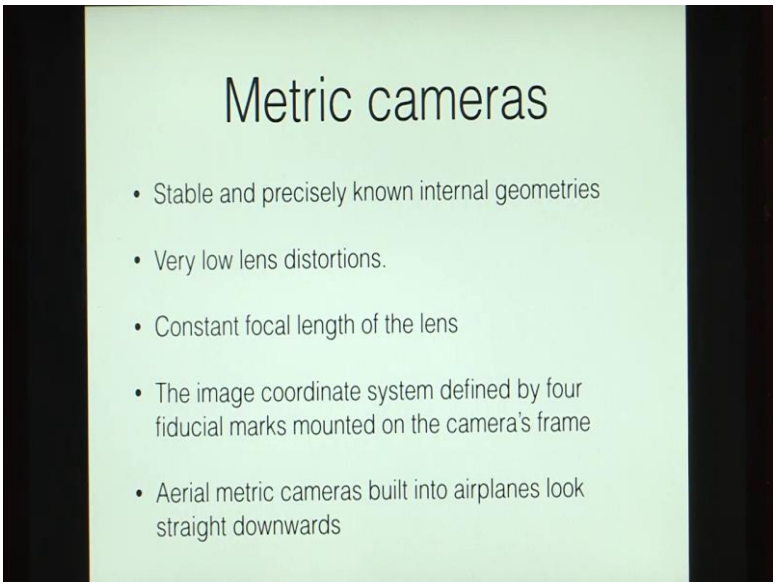

So, it has very precisely known internal geometries and these internal geometry are also very stable, which means that if you are taking this camera out in an aeroplane these geometry is are not going to be vary. So, they will be very watertight. This camera would also be having very less amount of lens distortion. It would have a constant focal length of the lens. So, the focal length of the lens is also not going to vary.

So, for instance in the case of our eyes the focal length of the lens varies, but in the case of metric camera it will be having a precise focal length that will not change. Also the image coordinate system will be defined by 4 fiducial marks mounted on the camera stream. What that means, is when we have this camera.

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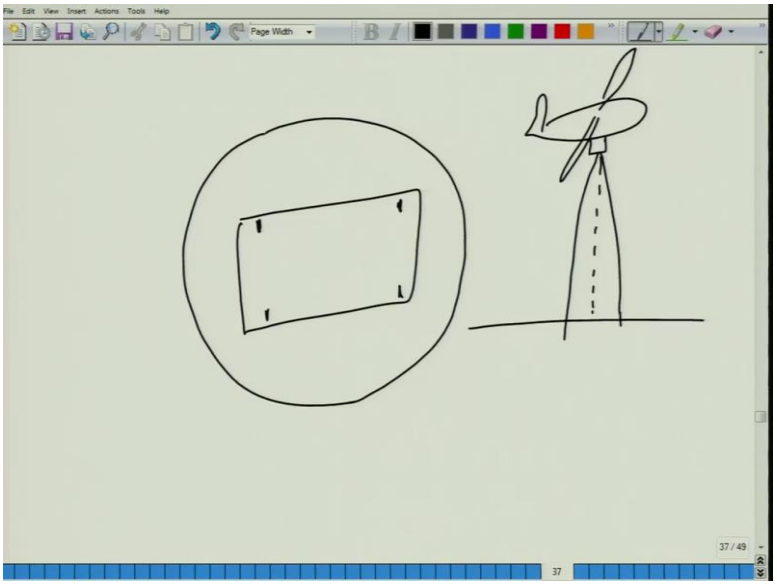

So, when we take an image that is taken from this camera it would be having 4 marks out there in the photograph, which would tell us the image coordinate system, so because these 4 marks are out there in the camera itself. So, there will always be there in on all the photographs and we can use these marks, to back calculate any geometries out there in the photograph.

These aerial metric cameras are built into aeroplanes to look straight downwards. So, for instance if you have an aeroplane and this is the ground your camera would be mounted such that it looks straight downwards.

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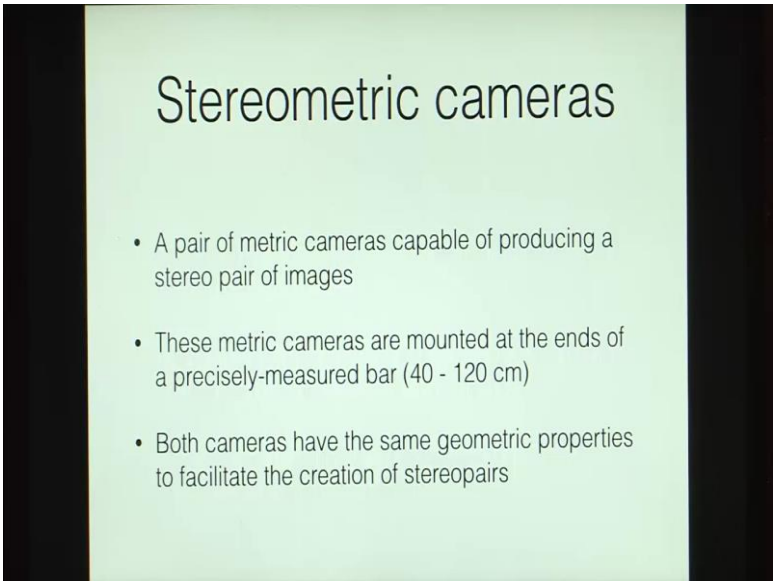

So, this axis would be perpendicular to the surface of the earth and it would be looking downwards. We also have something known as stereometric cameras. So, if you go back to the slide now. Stereometric cameras are a pair of metric cameras capable of producing us stereo pair of images.

What that means, is these 2 cameras that are mounted there on the aeroplane would be taking pictures simultaneously and because these cameras very much like our eyes. So, we have 2 eyes that are looking at the same object. So, they will be able to give us a stereo pair from which we would able to get all the depths. These metric cameras are mounted at the ends of a precisely measured bar.

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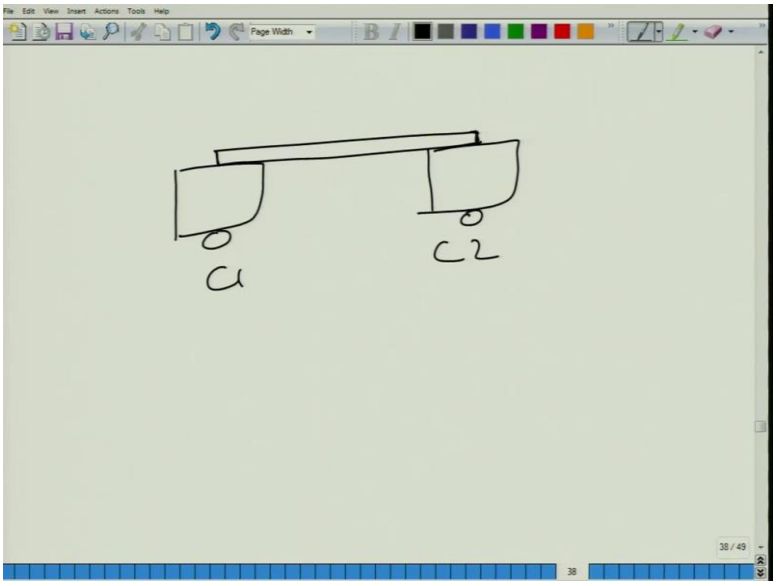

So, the length of the bar; so for instance if this is the bar, and we have a camera this is the first camera and this is the second camera: C 1 and c 2. So, these cameras are mounted at the ends of a precisely measured bar. So, this distance between these cameras is not going to alter between the flight. Both these cameras will have the same geometrical properties to facilitate the creation of stereo pairs.

So, what is a stereo pair. So, if you covered one eye with a hand and you see the object in front of you. So, you are getting one image if you cover the other eye you would be again see the same object, but when you say stereo pair you are seeing the same object using 2 eyes. So, this is giving you 2 images that are known as stereo pairs.

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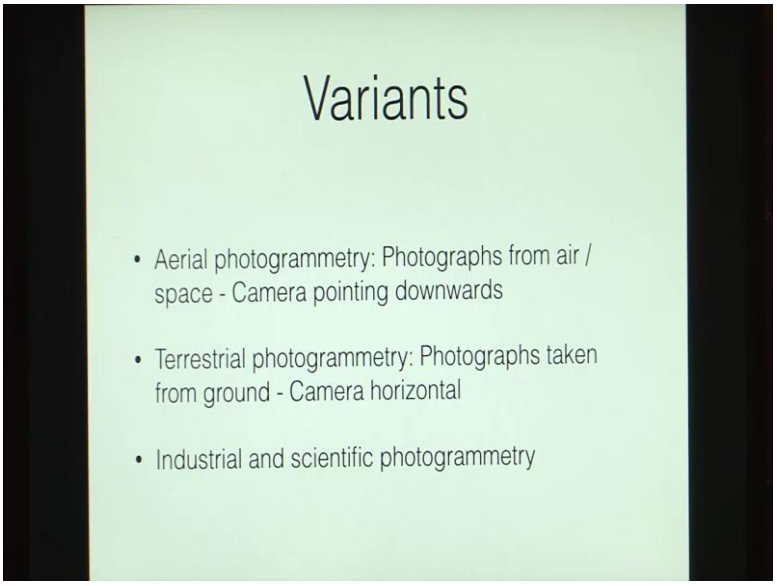

Now, what are the variants in these cameras? So, coming back to the slide. So, the variants in these cameras and the variants in the science of photogrammetry we have 3 things. We have aerial photogrammetry which involves taking photographs from air or space. So, in which case the camera would be pointing downwards, we would be having terrestrial photogrammetry in which we have photographs taken from ground in which the camera is horizontal. And we have industrial and scientific photogrammetry, which is used in the case of industrial applications.

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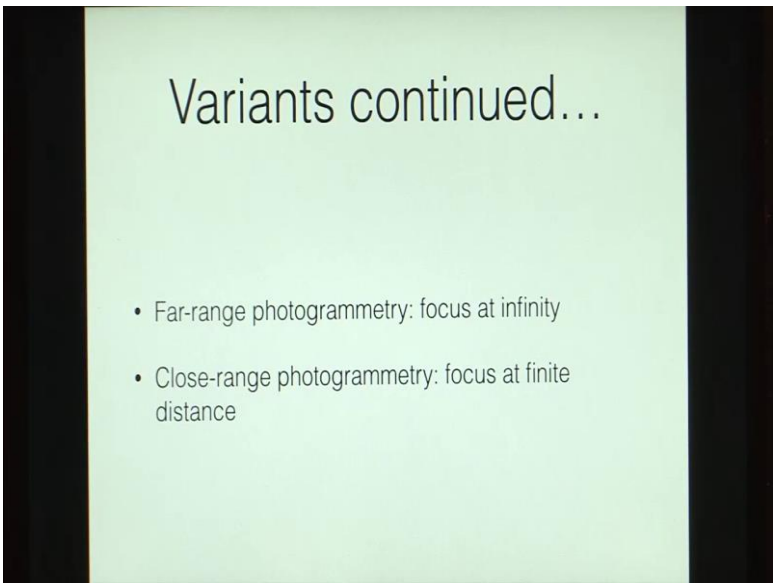

We can also have far range photogrammetry and close range photogrammetry. So, in the case of far range photogrammetry your camera is focused at infinity. Whereas, in the case of close range photogrammetry the focuses at a finite distance. So, for instance if you are if your camera is mounted on a plane and it is focused at infinity. So, it is focus to take images of all objects that are very far from the camera then it is known as far range photogrammetry, but if you are focusing your camera to such an extent that it takes pictures within a certain range.

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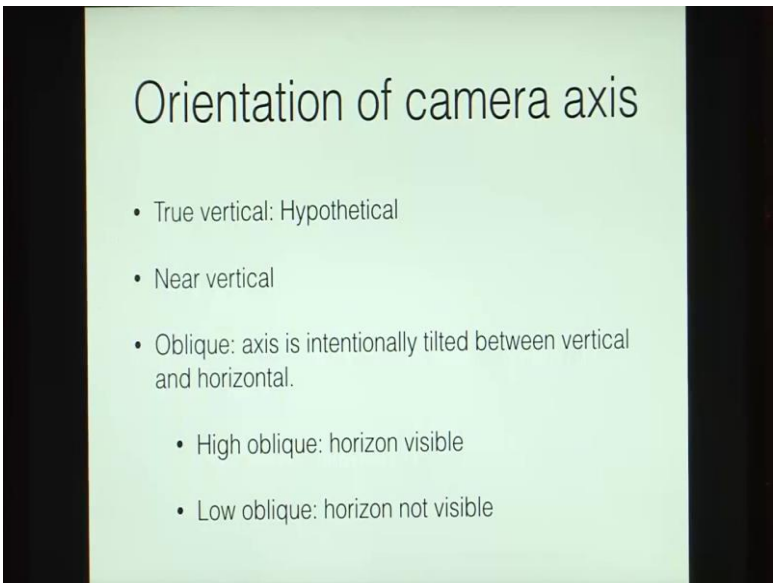

That it will be called a close range photogrammetry. Next we have orientation of the camera axis. So, orientation of the camera axis can give us 3 things. True vertical So, in the case of a true vertical photograph your camera is mounted looking downwards and the axis of this image or the axis of the light rays that are that are going inside the camera it would be perpendicular to the ground surface and perpendicular to the surface of the film. But a true vertical is a very hypothetical situation we normally usually get it because your planes might be tilting and twisting while there in the flight.

You can also have a near vertical photograph. In the case of a near vertical photograph this angle is close to ninety degrees, but not exactly ninety degrees you could also have an oblique photograph. So, in the case of an oblique photograph your camera is tilted. So, when is when it is tilted it takes the view from the top. And this view is not exactly

ninety degrees it is tilted at an angle. So, this angle might be called a high oblique angle or a low oblique angle.

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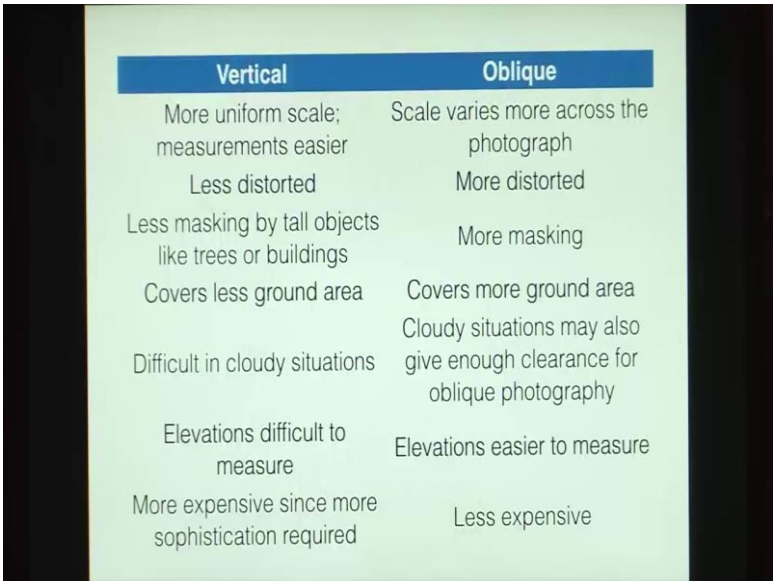

So, in the case of a low oblique angle you are not able to see the horizon, but in the case of a high oblique angle at all the times you can see the horizon. So, let us now look at the differences between vertical and oblique photographs. In the case of vertical photographs the scale is much more uniform and it is easier to measure. The photographs are much less distorted as compared to oblique photographs. There is less masking by tall objects like a trees or buildings whereas, in the case of oblique photographs there is more masking, what is that mean?

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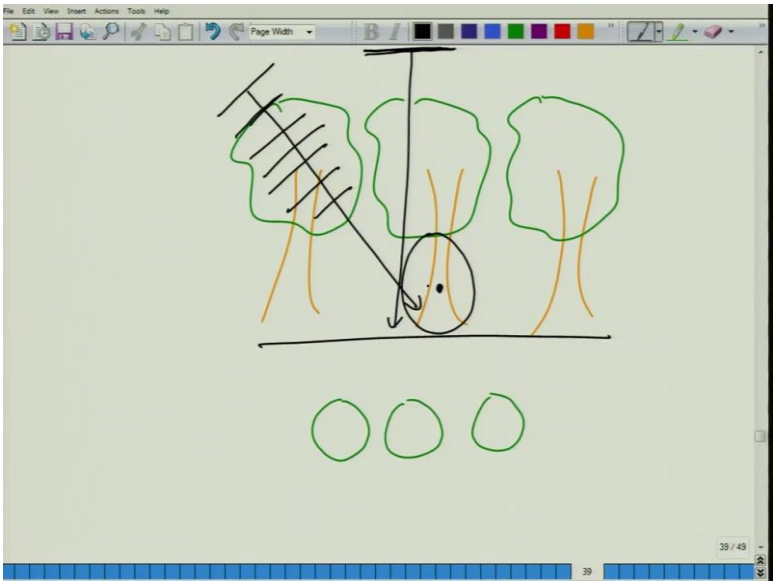

If we took the picture of a forest; so if you are taking the picture of the forest in a true vertical photograph. So, in the case of true vertical photograph your plane is parallel to the earth surface. So, in that case from the top you will be able to see these 3 canopies if you took a photograph like this then in this case this portion of your canopy is visible, but the portions of this tree that should have been visible like these portions, they would be mask by the canopy of this tree. So, the trunk here will not be seen, that is known as masking.

Now, coming back to the slide a vertical photograph covers less ground area as compared to an oblique photograph. A vertical photography is difficult in cloudy situations, because when you have clouds and when you want to keep your camera axis the plane of your senses parallel to the ground it becomes very difficult to take cloud free photographs. But in the case of oblique photography the cloudy situations may also give you enough clearance for oblique photography.

In the case of vertical photographs elevations are difficult to measure, but they are easy to measure for oblique photographs. Vertical photography is much more expensive because it is much more sophisticated you need to keep your axis perpendicular to the ground at ninety degree at all times, but in the case of oblique photographs it is less sophisticated. And so, it is less expensive.

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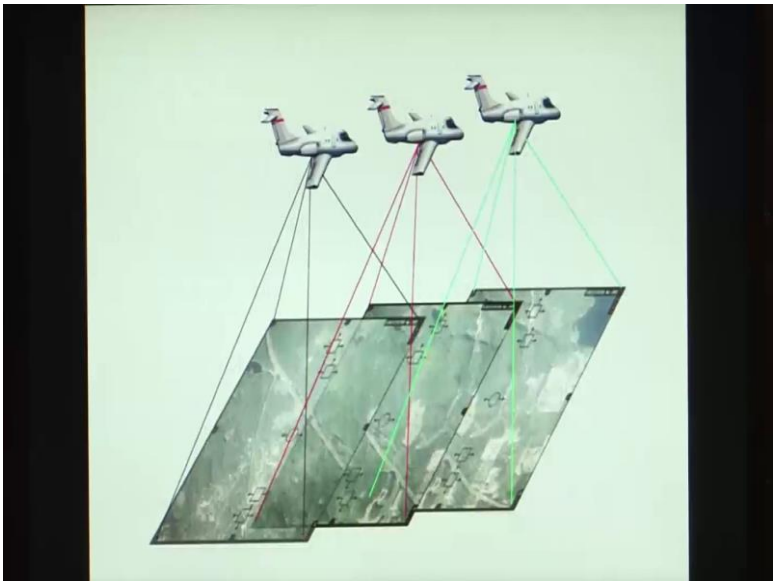

So, if you looked at an aeroplane that is taking pictures of the ground. So, here we can see 3 images in these 3 images some portion is common between 2 images and some new portion is taken in every situation.

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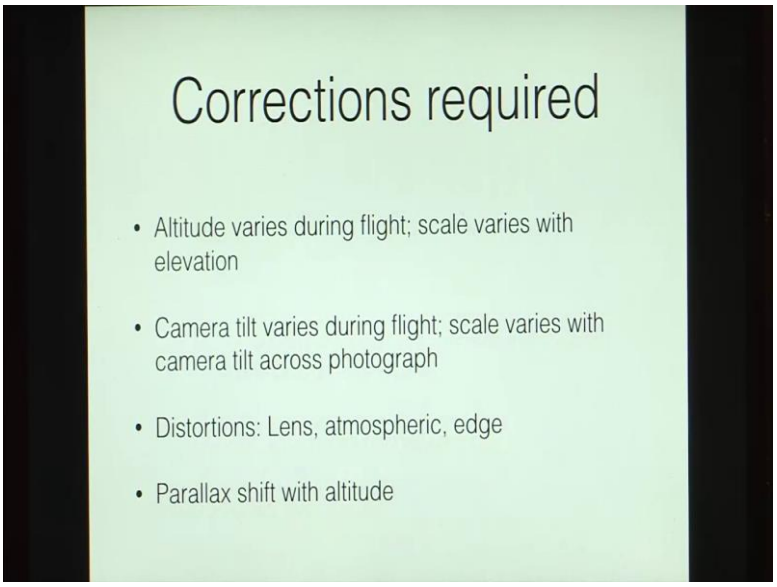

So, there are a number of corrections that are required in photogrammetry. Your altitude varies during the flight and when the altitude varies the scale varies with elevation as well.

The camera tilt might vary with the flight and the scales will vary with the camera tilt across the photograph. You might also be having a number of distortions lens distortions atmospheric distortions and edge distortions. So, that need to be corrected, and there will also be a parallax shift with altitude.

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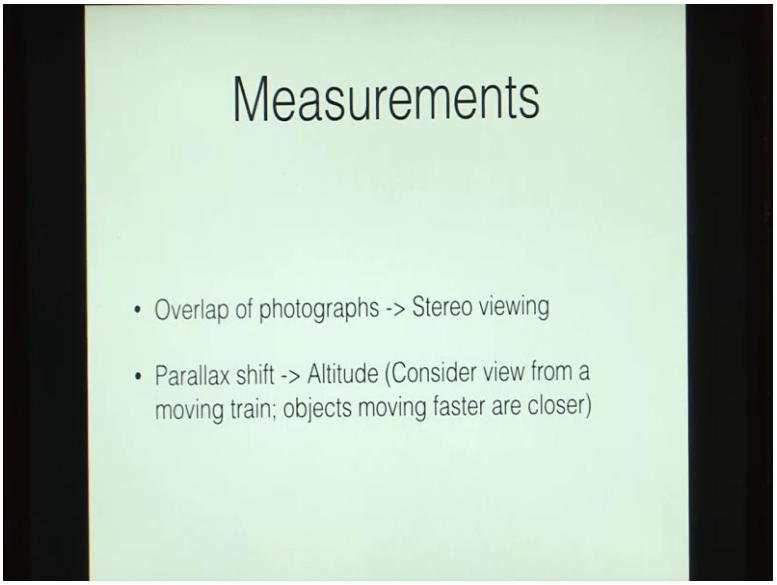

Now, how do we take these measurements? We take as we saw in the previous slide when we are taking 2 photographs these 2 photographs will be having some amount of overlap to permit as stereo viewing. Now stereo viewing means that you are taking this the image of the same object from 2 different locations.

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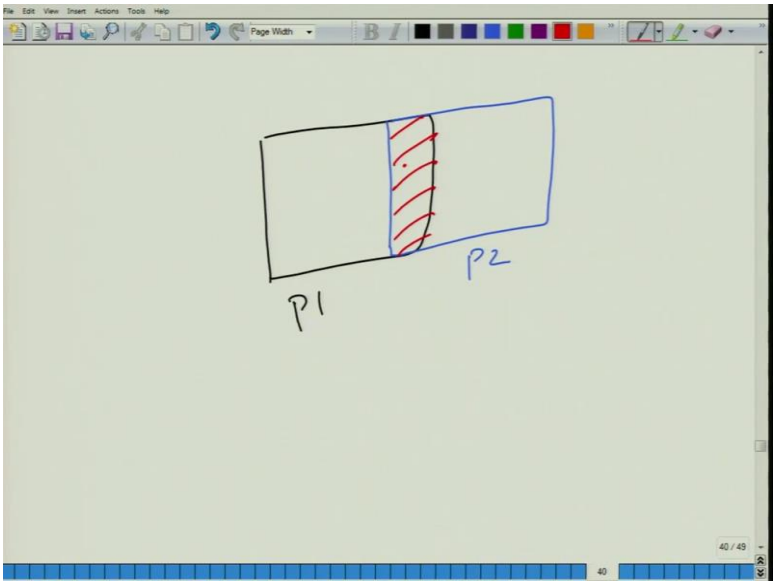

So, for instance when we have this as the photograph one, and this as photograph 2. So, this is p 2 and this is p 1. So, this region is common between both these photographs. So, any point on this region would be photographed from 2 cameras at 2 different locations which giving us a stereo pair. So, that would permit us to perceive the depth across this photograph.

Now, coming back to the slide, will also be measuring the parallax shift which would give us the altitude. So, what do we mean by parallax shift? Consider the view from a moving train. So, when you look outside the window of a moving train. You can see all trees and all objects that are outside as moving in the opposite directions, but the objects that are closer by will be moving at fastest speed as compared to the object that are far from you. And the object that are very far might even appear moving parallel to the direction of the trains. So, that is known as the parallax shift.

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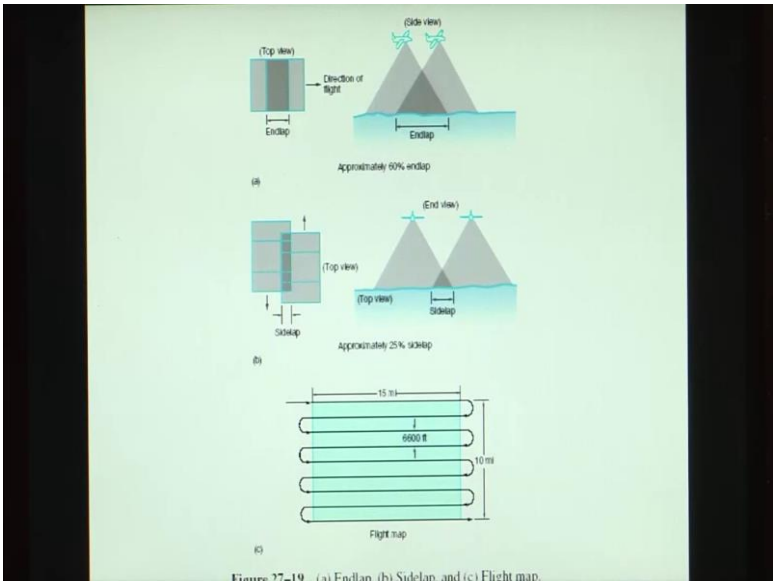

So now coming back to the slide. This shows us the overlap between 2 images we have an end lap we have a side lap and we can see the flight map. So, this is generalizing. So, what are the applications of aerial photography?

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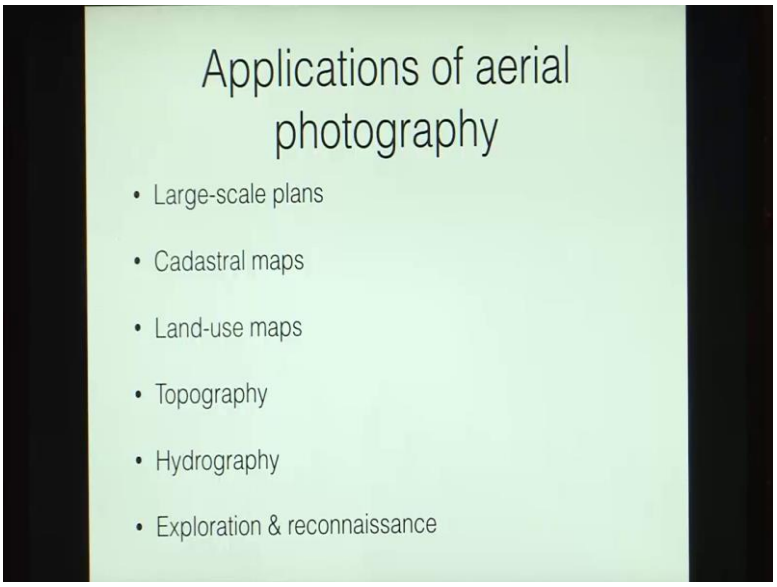

Well, as you can see in the slide we have a number of applications. Like the preparation of large scale plans in which you see a large area a last vast expanse of area on a photograph. You can also use it to make cadastral maps in which you show a small area at a larger scale. You can also use it to prepare land use maps, which tells us how each

parcel of land is being used you can get topography which tells us the elevation and the position of various objects in the ground it can be used in the study of hydrography and also for exploration and reconnaissance missions.

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Now, what are the by products or tape other products that we can get out of photogrammetry? Well, we can get digital elevation models now a digital elevation model is computerized representation of the earth surface area. So, it will also show you different objects and different heights and different distances. You can also take orthophotos from photogrammetry; you can use the information to in the preparation of thematic GIS maps.

So, GIS refers to geographical information system and thematic maps give you information. So, it can be used in the preparation of computerised data bases which based on different applications. And you can also have some other derived products and maps.

Thank you for your attention, [FL].