Geographic Information Systems
Prof. Bharath H Aithal
Ranbir and Chitra Gupta School of Infrastructure Design and Management
Indian Institute of Technology-Kharagpur
Module No. #03
Lecture No. #15
Representing the Real World (continued)

Hello namaste, welcome back to the course information system today's lecture is the continuation of the previous 2 lectures where we have looked at different data models**.** The first thing that we looked previously was how do we do additional terrain model okay. So when I say digital terrain model it represents the terrain surface of the earth area. So that is what we looked at what is a digital terrain model that we translated into digital surface model, which is actually representing anything on the surface very overlaid all this things on the surface to digital terrain modelled.

Then it is called as a digital surface model, then we look that digital terrain model is a 2.5 d representation whereas digital terrain models is a 3D representation digital elevation models is a 3D representation sorry about that. So, once we have looked at that model then we looked at the grid model. Grid model we clearly understood that it is each grid that this farmed is a collection of cells.

And every cell is an approximation of the region that is below to appoint, so which means the state has only one value and it does not give varied value across that particular set. So now how do we represent this particular thing is by the gridded representation that is what we have looked at the previous class.

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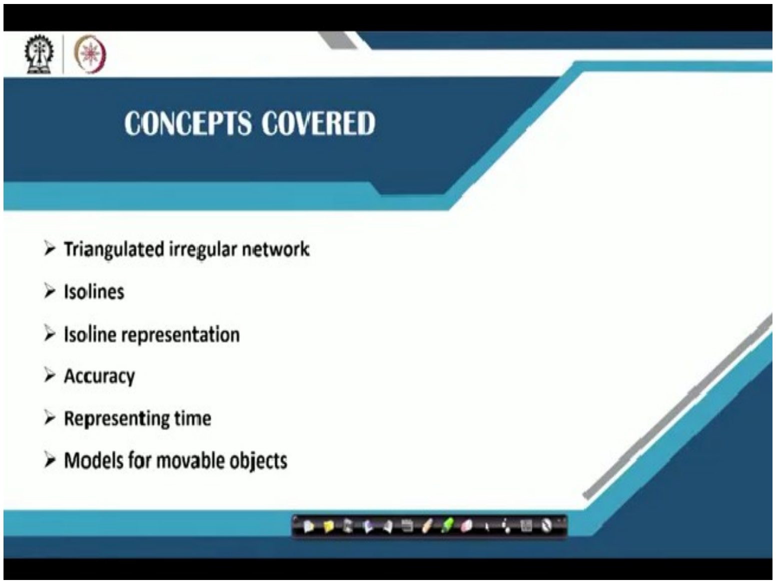

In today's class we would be translating into understanding triangular irregulated network or a regular network. So this is one kind of modelling a model very well-known in kind of representations of such datas. Then other model that is very well-known and people have used it most of you have come across it in one of the other forms is nothing but isolines.

We look at isolines, we look at triangle irregulated network, then you look at accuracy why accuracy is important, and what are the factors that is affecting the accuracy, then finally, there is a thing that we have to understand is representing time when we are doing a temporal analysis, we have to represent time, how do we represent time, is there a way to understand and represent time.

That is also the thing that we look at in the slides and finally we would look at in this class, the model for movable objects or whatever we are looking at this more of a stationary subject and it is quite subjective. But, when we are actually modelling the real phenomena, there is actually moving, we find a lot of moving objects in the real world. So in order to represent that do we have a model.

Yes, we do have a model that is called in a network model. So we look at network model also in this class, and that that would end this class. So first let us get into the triangular irregulated network.

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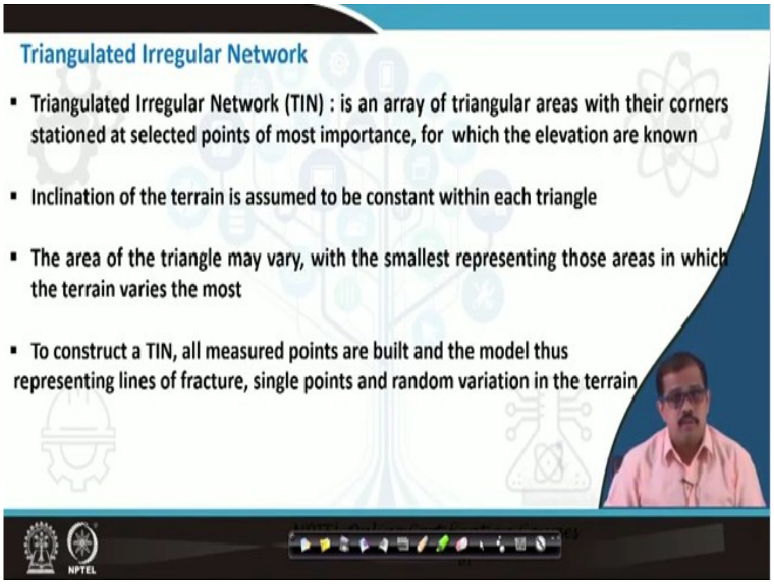

Triangular irregular network it is actually an array of triangular areas. So, when I say triangular areas it is an enclosed polygon okay with their corners station at select selected points of most importance for which elevations are known. Please be careful of this, when I say most important it does not mean that it is an important place on the surface, it means to say that where we know the values that point on the earth's surface is selected as a nodal point.

So now with this point as a nodal point we connect the other nodal point, which is known. similarly, the triangles are built with different nodes and finally that becomes the representation of the earth's surface. Then inclination of a terrain is assumed to be constant in this each triangle. So here also we have an approximation unlike the grid model here we inside a triangle, we assume that that particular value is remains constant okay.

So that is what is about the triangular irregular network, the area of a triangle a vary with the smallest representing those areas in which the triangular varies the most okay. So now terrain varies the more sorry. So, when we say when there are terrain values that are actually changing that is where you have the smallest of the triangles. The largest of the triangles is where you have a least variation in the entire terrain.

To construct TIN all are that it is also called as TIN it is a TIN model, all measured points are built and the model, thus representing a line of fracture single points and random variation in the terrain is developed. So I will show you some of the methods of how the TIN model is built.

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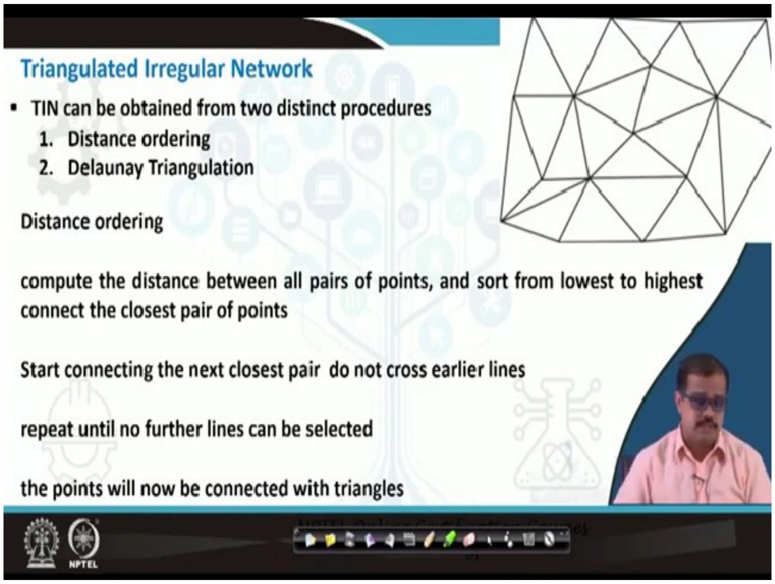

TIN model can be built using 2 distinct procedures. One is distance ordering and one is delaunay triangulations, but when we look at both of these delaunay gives a translation gives you much is more advantageous when you are using the triangular irregular networks. So we look at why disadvantages also. But first, let us understand how do you do in distance ordering. So, how the first thing is compute a distance between all pair of points and sought from the lowest to the highest and connect the closest pair of points okay.

So for example, I know this point, I know this point, this is the point of variation, this is another point of variation, this is another point of variation this is another point, this is another point. The first thing that I will do is I will calculate all the distance between these points 1 2 3 4 5 6 7 okay. First thing is I find that the distance between these point and then sort it from the lowest to the highest. Let us say the distance between these 2 points have the lowest. So, I will start connecting the closest pair of points.

First I will connect this, so this is assumed to be second lowest and once we have done this then will connect these 2 different nodes okay, then start connecting the closest pair the okay that do not cross early lines okay. So only thing you should remember that in this kind of network the line should not cross each other. So, will connect this, then connect these 2 so that it does not cross ok.

Repeat this procedure until there is no further lines that lines can be selected in the entire network. okay. So, the points will be now connected with as triangles, this is called the distance ordering. Each triangle is representing a particular set of region where there is absolutely no change in the terrain. So, it is representing the terrain values. That is one kind of modelling as far as distance ordering is concerned.

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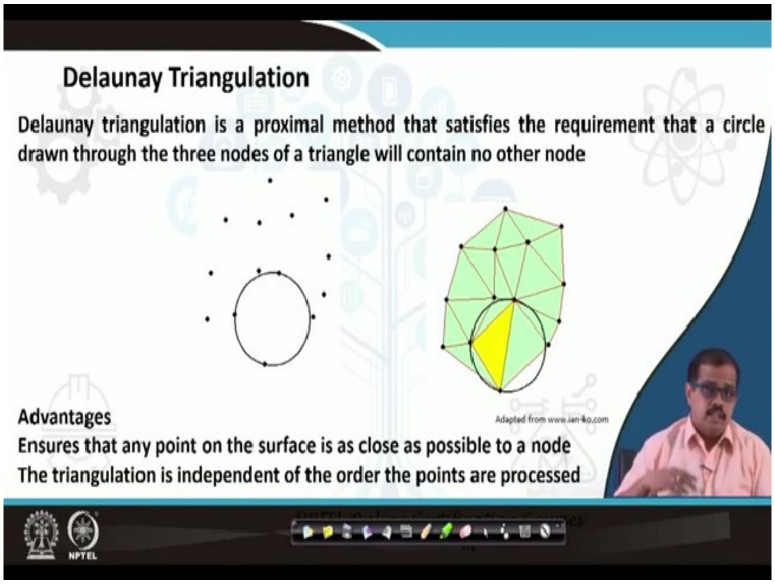

There is another way of looking at TIN model is delaunay triangulations, when you look at delaunay triangulations it is actually a very proximal method that satisfies the requirement that a circle drawn through the 3 nodes of a triangle will contain no other node. So that is what it has to actually precisely tell you, once you have drawn the triangle as I have already spoken to in the distance ordering the circle should be drawn in such a way that through the 3 nodes of a triangle and will contain no other node, they it has to satisfy this.

For example if I connected these 3 as three nodes when you draw a circle, it should not cover any other node. So this is one of the very efficient methods that is available, when you look at the TIN model. So what a when we look at this it has several advantages okay. But, having said this, TIN model is also the industry standard are developed by specifically with ARCGIS as a software, it has grown over the years.

And you can see large number of methods used for such models and when you look at the advantages it ensures that any point on the surface is as close as possible to the node okay which means say that it is actually giving information of every node, every surface and every point on that is been represented. The triangulation is independent of the order the points are processed. So that is what is extremely important when you look at the distance based method you have the lowest distance first and the highest distance last that is connected.

But here we do not have that aspect okay. So, once we have connected a triangle okay. So, this any 3 nodes that is forming a triangle, draw a circle and see that it does not fall into that particular, there is no node that is falling to the circle. Once this criteria is solved so the most the triangular irregular network is actually built upon okay.

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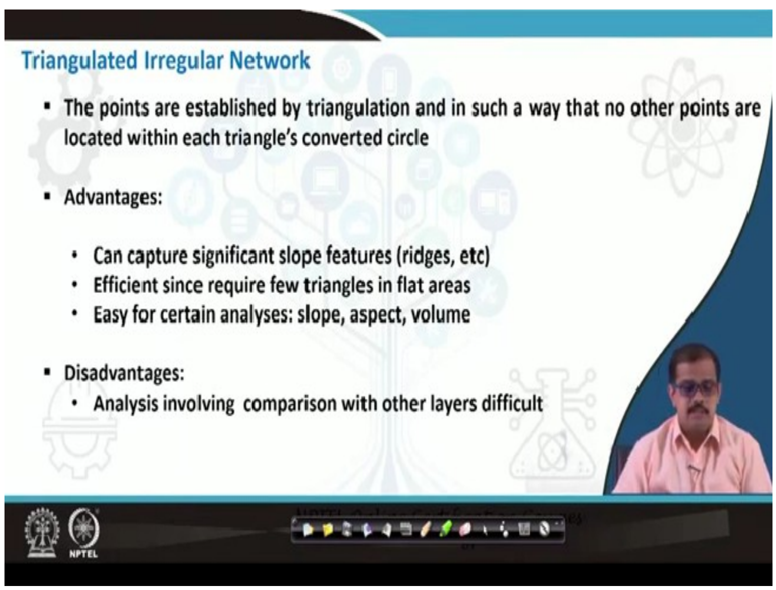

So the points are established by if I have to define TIN in a very simpler way. The points are established by triangulation and in such a way that no other points are located with each triangles that is converted to circle, that is what I mean by the previous one. So I have already said what are the different advantages and what the only disadvantage that we find delaunay triangulation is analysis involving the comparison with other layers is extremely difficult.

So that makes it aspect a really difficult in terms of when we are trying to analyse layer by layer issues that has to be seen in the entire database. Otherwise, it is an excellent method of obtaining TIN model and TIN model is considered to be one of the efficient models that is available in industry today.

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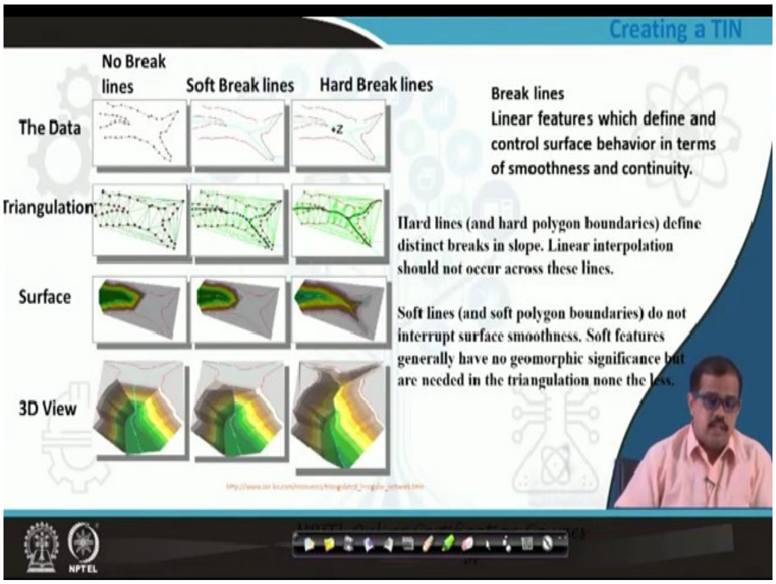

So I have just given you a representation of this, this was actually adapted from young core wherein this entire description of this particular image gives you exact way of how a 3D view is developed. First, the triangulation is developed, then how the surface is developed and finally the 3 D view is developed. The first thing that we have to understand as brake lines.

Brake lines are linear features which define uncontrolled the surface behaviour in terms of smoothness and continually, that is what is called brake lines. So, for example, here you have a brake line which is actually there are no brake lines here, it actually continues all throughout. But when you see in the second image here. So it has a brake line, if you see here. So this image has a brake line, when you have see these are certain brake lines, a software break line. Whereas, these are hard brake lines okay.

So if you see here, there is an. So when we are looking at this one the hard lines defined the distinct breaks in a slop, that is why you need a hard line. So it actually says where are the distinct values that break in a slope okay. Linear interpolation should not occur across this line this is what is an I mean a constraint here, they should not be any linear interpolation in the entire set. When you look at soft lines did not interrupt this the surface smoothness soft features are generally have no geomorphic significant but are needed in translation and the less.

So you need is soft line, you need hard lines, but hard lines have a distinct breaks whereas soft lines not have a distinct breaks that is the distinction between a hardline and soft line. So now we have this data. so, with no brake lines, we have soft brake lines and we have hard brake lines. So when you look at this let say we are actually deriving this strangulation by anyone of those methods okay.

So, once we have done the triangulations here you can see number of triangles that are representing the same surface on the earth surface which means elevation remains constant across all okay. So when you have hard by a brake lines you can look at number of surfaces here. So, once you have done it, the entire surface data is then overlaid on this aspect okay. So, once you have done now you have the + z values where + or - z values.

So this can be looked at in a 3 D view. So, this is what is a representation of this particular 3 D view. This is rotated across, this is actually the one that is here as been rotated to the -90° so that you can see this is the way it is represented. So, this is where you have lower point and this is where you have the higher points that is the + z values. So this is how a triangular irregulated network is built and then converted into a 3 D view okay.

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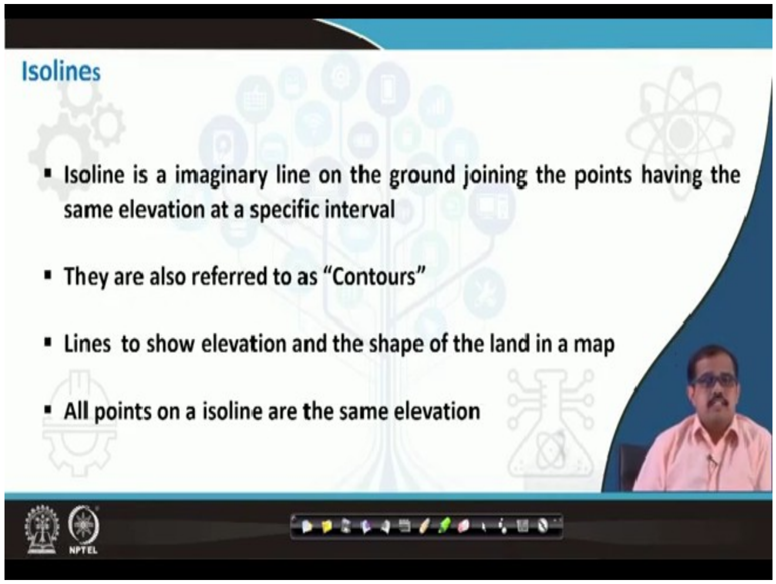

So the next method that we would look at is the isolines. Isoline is an imaginary line on the ground joining the points having the same elevation at a specific interval. I hope rather than isolines you have heard about a specific term called as contours right. So, contours is also referred to as isolines. Line is that your elevation and shape of land in a map and all of these isolines are joined to the points having the same elevation and do not cross each other. That is the very important part of it okay.

So, when I say isolines it is you should understand that these are the points that is actually joining the ground with same elevation and are also called as contours.

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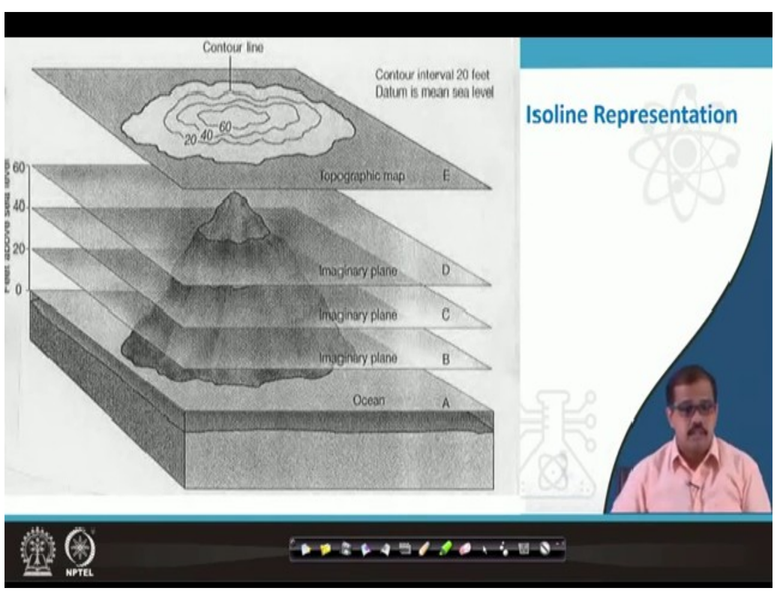

I have shown a representation of an isoline for example, this is your let us say the ocean okay, a is representing the ocean. Now, when we draw an imaginary plane, we get a the surface at our 20 feet, next another imaginary plane C is drawn, wherein you get surface at 40 feet under imaginary plane is drawn when you get surface at 60 feet. The same is represented into a topographic map something like this.

You have a topographic map here, wherein you have 20, 40, 60. So, this 60 you can see these lines are representing never criss-cross each other and are representing same elevation on the map. That is why we call it as an isoline okay. So this is how we represent an isoline. So what we have seen here as isoline interval is 20 feet that we have considered here, datum is the mean C level that we have considered.

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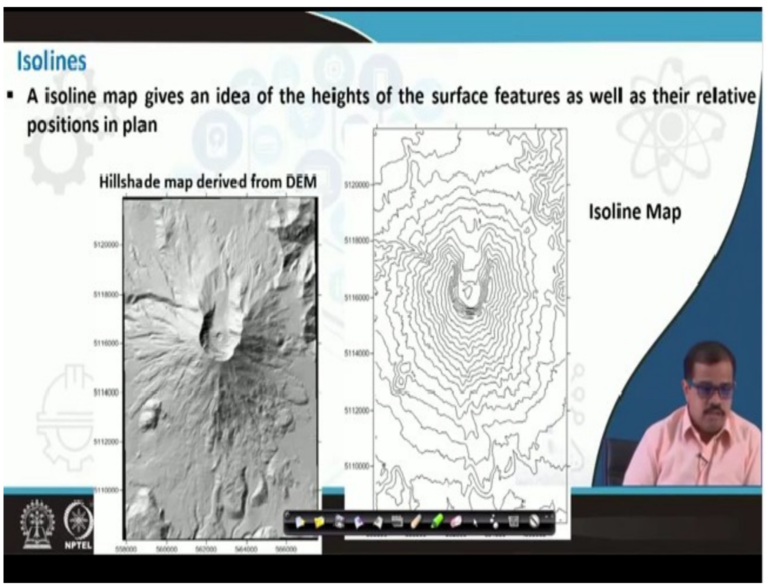

So and it also gives an idea of height that is why we use of isoline in wherever you need the idea of height you can use an isoline a surface features as well as relative position in the plan is shown. For example here this is an hill shade map that has been developed from the DEM, will also develop the hillshade map in our practical classes, when we look at this hill shade map or you can see various features on the ground that has been denoted.

And when you look at the same in the isoline of map you can see where there is the highest of our evaluation and where there is the lowest elevation, if you see highest elevation is of very close to this point here and lowest elevation is somewhere here okay. The same thing is represented here, the highest elevation is here.

Whereas the lowest elevation is here and please mind at that no contour criss-crosses each other no isoline criss-crosses each other okay, so that is a very important point that where students make a mistake that they draw a contour seen in terms of sometimes it crisscrosses each other. Please see that it does not I mean, that is a wrong way of representation.

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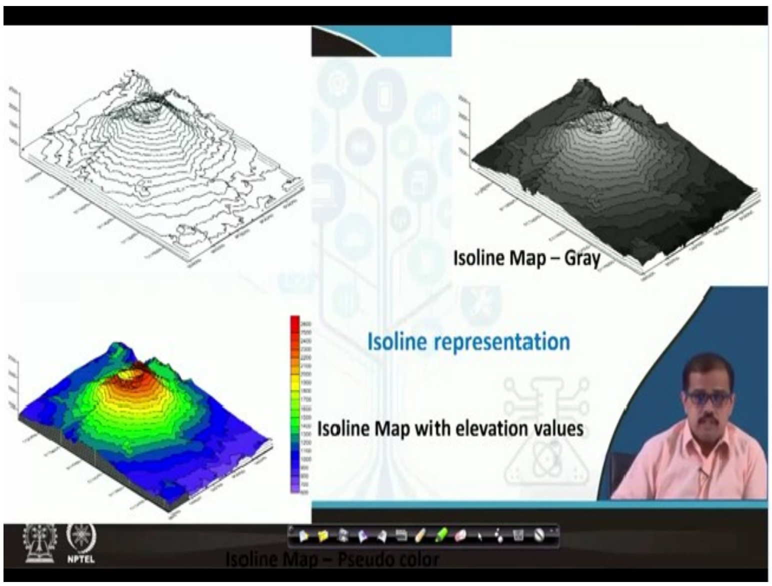

Now, so these are some of the isoline representation, so can see this is the elevation values have been added here, you can see these are the elevation we have generated a thematic map so that you understand this and this is a normal isoline representation and this is in the great value shades. So you can see the lighter shades actually representing and elevation that this at a very high elevation and the ground at a lower evaluation is represented in grey complete grey or closer to black.

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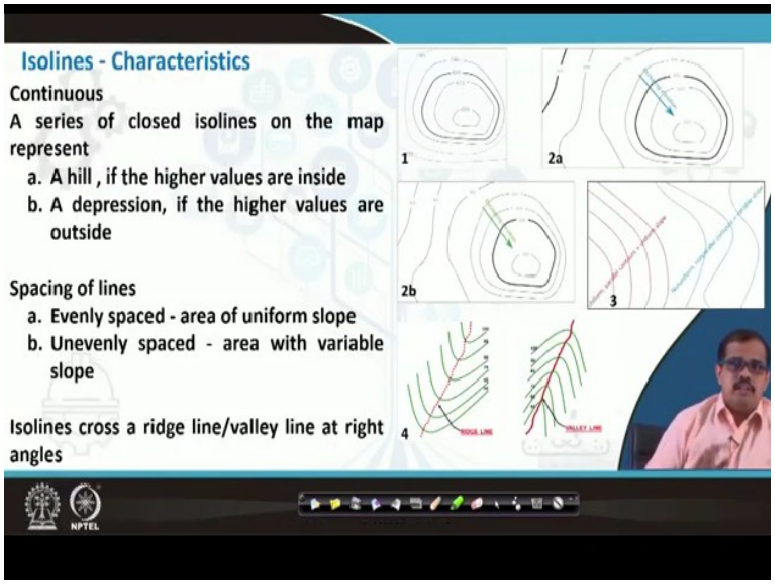

So what when we look at isolines, they have certain characteristics one is it is continuous a series of close isolines on the map represent a hill if the higher values are inside okay. So keep this in mind when you are actually representing you always it has to be understood that as if there is a series of close isolines, then it is actually representing higher values that are inside a depression if higher values are outside is if it at the higher values are outside and it is a depression.

So here, when you look at here you have 590s, 600 610 and 620. So, higher value is inside. So, it is actually representing the hill or higher elevated region is represented by this. Whereas, when you look at here 620 600 610 as it goes to the lower elevation I am sorry this is the decreasing elevation here. So when you look at this this is giving your depression okay. So, it is from a higher elevation to the depression region okay.

Then spacing of lines, so there are people who have developed the isolines who have develop contours, but very important point as they forget is how you space a line, line should be evenly spaced with area of a uniform slope. So that is extremely important, the slope should be extremely uniform if you draw, if you start drawing a line at 20 feet interval as I have shown previously.

And suddenly you start looking at the values at 40 feet and then 60 feet where interval is 60 feet. So, then it is not a true representation of the particular surface, that has to be characterised at 20 feet all throughout ok. Then unevenly spaced areas with variable slope. So, if you have a variable slope then only you have unevenly spaced regions. But when we are looking at isolines normally the model is always evenly spaced only in terms of for example, when you are looking at certain regions which are completely uneven.

Every point is actually changing that is extremely difficult to get, in such cases, only then you have isolines representation which is uneven. Otherwise, it has to be even, then isolines cross a rich line where value line at right angles only. So please keep this in mind okay.

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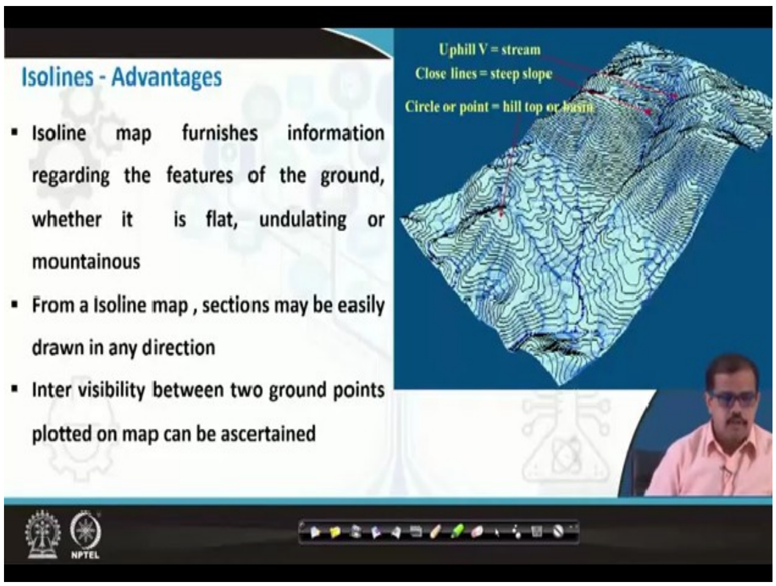

When you look at other advantages it furnishes information regarding the features on the ground, whether it is flat, undulating or mountainous. I give an example in the previous slide on if the isolines are an increasing fashion, then it is hill, if it is decreasing fashion, then it is a depression. So similarly, when you have isoline at the furnishes information, whether it is flat, undulating or mountainous that is what I explained in my previous example.

From the isoline map sections may be easily drawn in any direction, so that is another point that you have to look at it. Each sections can be understood and drawn in different directions. Inter visibility between 2 ground points plotted on the map can be ascertained. So, this is of use to many applications. So inter visibility of any 2 ground points can be plotted and ascertained if you have an isoline model.

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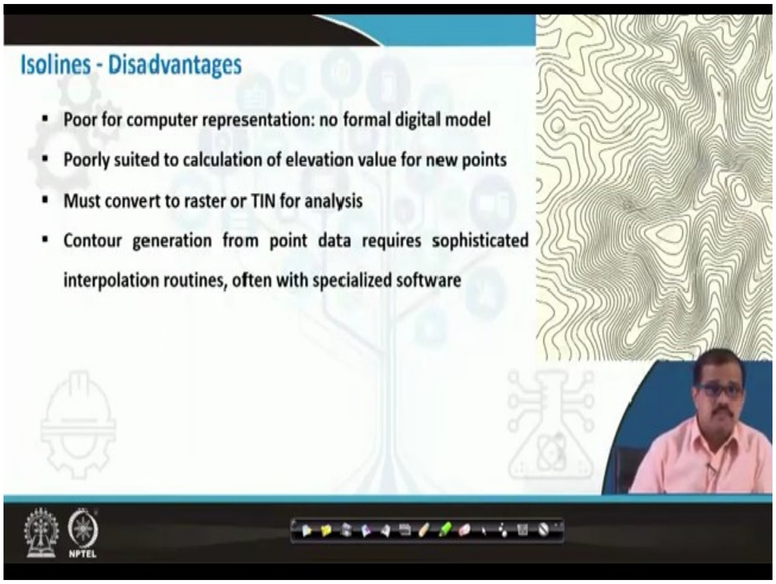

But there are certain disadvantages that people have to look at, so some of them are poor for computer representation. So you do not have any formal digital model, which is supporting this only suited for calculation of elevation values of a new point okay. If you are trying to or calculate the elevation of unknown points then it is quite difficult to understand it, then must convert a raster or TIN, for any kind of analysis.

Otherwise, you cannot do any analysis on using an isoline, then you the contour generation from point require sophisticated interpolation routines okay, often with specialised softwares. Now a days as most of the software can handle it when I say specialised software, softwares, with which are specialised in terms of GIS. So, GIS tools and signs.

So, the contour generation from point data, so you need specific tools or specific signs space tools on geography information systems only then you will be able to generate any data from isolines. So, any of those freely available software or even GIS map info, all of this softwares can generate any of the contours from your point data.

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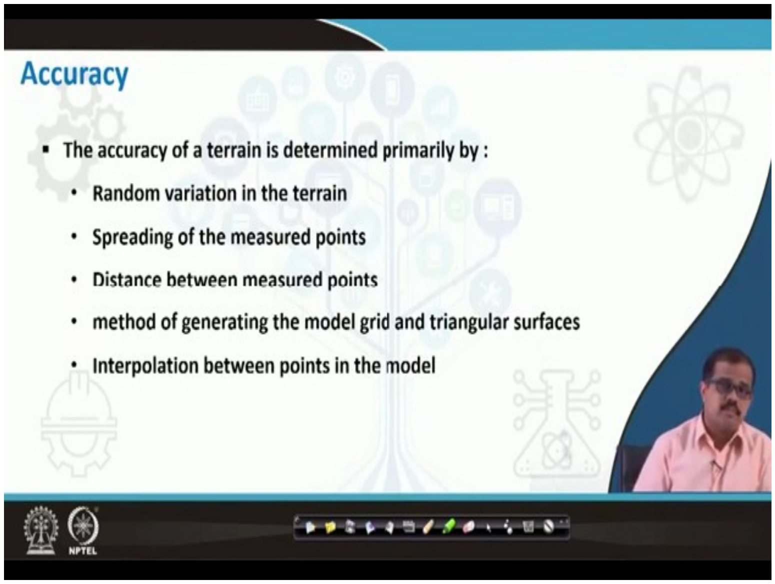

So, coming to accuracy, accuracy of the terrain is determined primarily by various issues. One is random variation in the terrain, how random is the variation in that particular terrain, then the spreading of the measure points. So, have you collect, how was the points been mentioned in the entire model, is it mentioned as a group in certain corner or is it has a random measurement all throughout the place or it you have points all throughout your place.

For example let us say that there are only 3 points in the entire region that you are trying to model and those 3 points are in one node corner. So, what happens is the spatial variation represented only in that corner. Whereas other points will be given the same variation as the last point that you would have looked at. So that is what is the thing that people have to look at, you should have lot of measured points.

So that you know how the spreading has happened, you have to understanding of the whole terrain. Otherwise, you do not know the terrain characteristics at all. Then distance between the measured points. So, if it is as I said if the distance between the measure points is smaller then it is a better polygon than having a larger distance polygons in terms of when you are developing a model.

Then method of generating the model grid and triangular surfaces. So, the way it has been developed and the way it has been stored is extremely important. Finally, when you are developing model from a point you use certain statistical techniques like interpolation. So interpolation between points in a model, what kind of interpolation has been done okay. So, such kind of is the things are needed in order to determine the accuracy of the model ok.

It is not a straightforward answer to say what is accuracy of the model, but you have to look at all of these parameters are basically these 5 parameters and there are many more, but these are the things that the people have to keep in mind in order to see how accurate the particular model may be.

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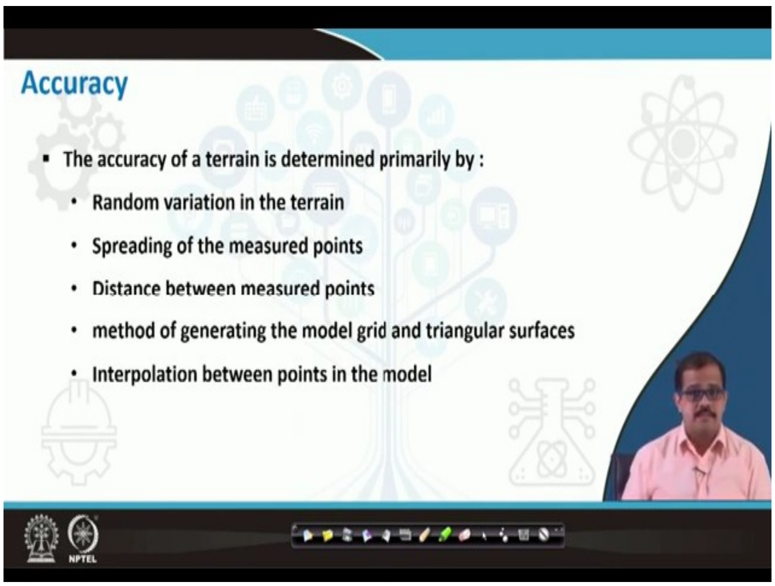

So, I also said that in certain models, we have to represent time. So how do we represent time in the real world time place a very, very important role where things change. So attribute and geometry, these are 2 things that we see in a topological change of an object with time okay. Attributes change for example, if you are trying to build the database of the roads, roads in Kolkata.

So the attributes of that particular road may vary every 5 years when it is tar when it is whatever the changes that happen in that road or widening of the road happens. So those of the attribute the change and along with the change that the geometry also changes. So that will change with time right. So this has to be incorporated, I can say the time as an attribute every 2 as I said every 5years that becomes an attribute.

So, to the objects in the same way of as the other attributes**,** so this particular approach will not create any logical connections between various the time layer, but it gives you a meaningful information of how they evolved aspect of time. For example, there is an attribute that has evolved over a period of time, but it does not give you any logical connection.

It only says that from this particular time to this particular time is evolved over a period of time. So when you say is that such attributes have evolved a period of time, it gives a meaningful information to anyone who is actually looking at how the real world has translated from 1 year to the other year. So that is how we start looking at representing time.

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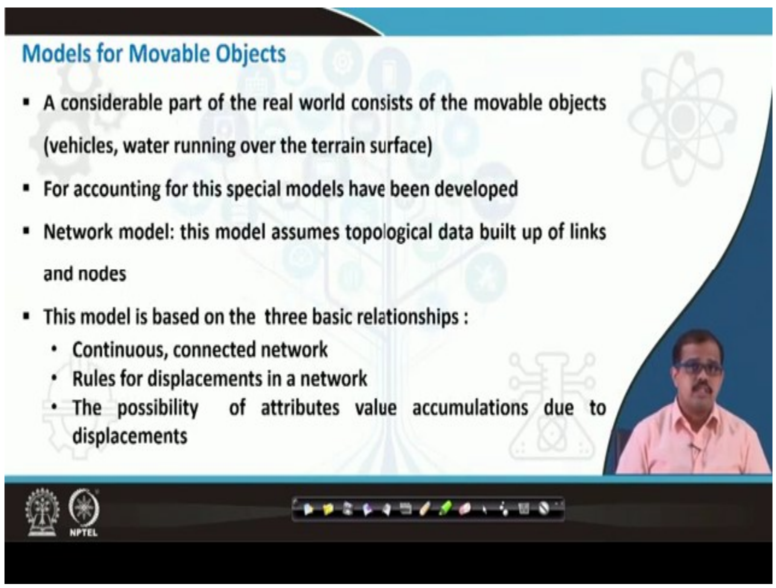

And the next thing as okay, so now till now we have looked at representing a static object okay, house, road, industries, all of the stuff, but when we have to represent a moving object that is extremely important in a real world model without having a moving object model is never built okay. For example, if you have vehicles that is going on the road, so that movement is nothing but has to be captured by your model, then water running over the terrain surface has to be captured by your model.

So, in order to capture this you need a certain model which can address this issues. So for accounting this we have some model call as a network model, so network model assumes topological delta built up of links and notes okay. It is a topological data as I said previously that is built up of links and notes. The model is actually based on 3 relationships. One is a continuous and the connected network, then you have a rules for displacement in a network, then the possibility of attribute value circulation due to displacement okay.

So, all of these 3 things are built as relations that is first is connected network, where the connections are for example, if you are looking at vehicles and the road. So different in the complete network then rules for displacement in a network where it can be displaced on which direction if you are considering the vehicle, then the possibility of attribute value of accumulations due to any displacement that is happening.

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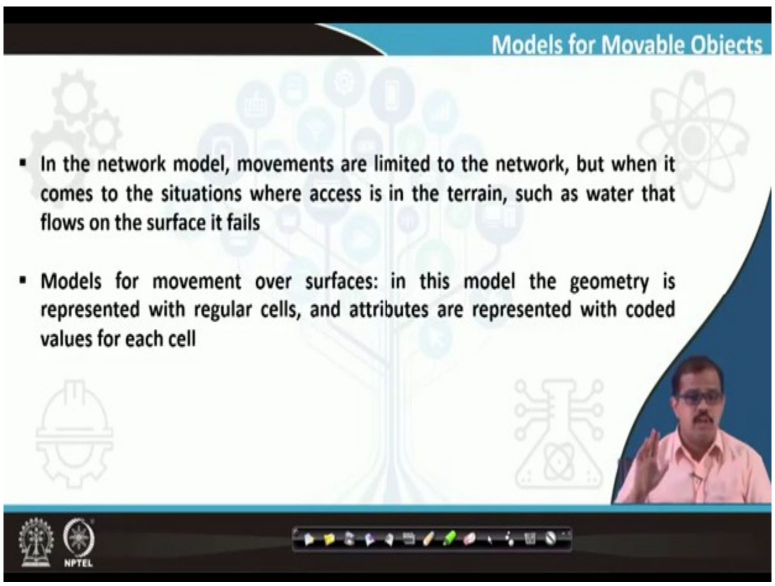

So this is what we have to look at, but in a network model movements are limited to the network, but when it comes to a situation where access in the terrain such as water that flows on the surface okay, you cannot really capture in a model. So that fails. So, if you really want to look at something that is all looking at how the surface water is actually moving, then you should have a geometry that is represented as a regular cells.

If you can represent that movement as a geometry of regular cells and attributes are represented with a coded values in of each cell, then your entire network model can represent events such as the water flow on the surface. So the thing that we learnt, we have a network model, but network model without geometry of representation over a regular cell is representing any of those wherein you are not looking at the surface flow like the water surface flow.

But in case you use if you can access about the details about the terrain you have to look at something that is with the geometry and with the regular cells. So, if you have understood the geometry with the regular cells into the model if we have put all those details into the model then that model can efficiently model any process any natural process much efficiently.

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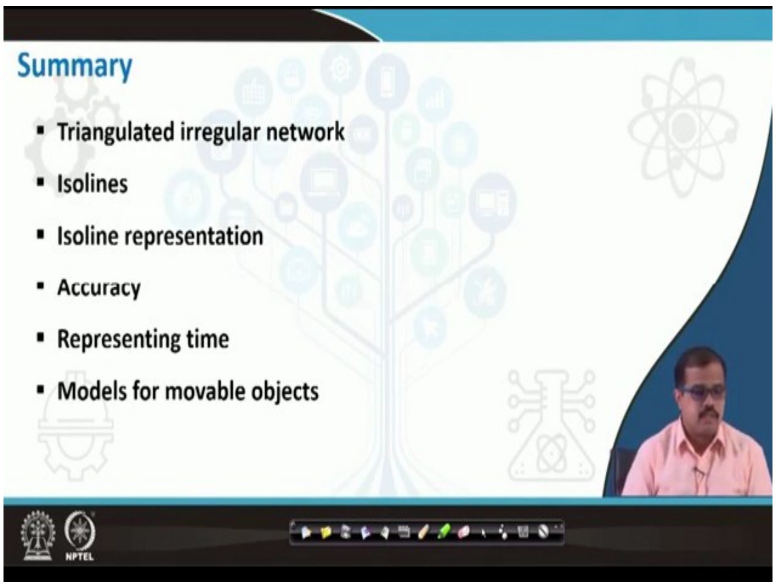

So, coming to the summary of this class we first started with triangular irregular network wherein we looked at how the TIN models are built, there are 2 types of ways of building a TIN model. The first thing is we looked at that the distance space method then we also look at triangular triangulated method. So, those are the 2 very basic methods of how a TIN model is being built.

So we look that the advantages of that the different models and how these models are built. I also gave an example of how this models are built, then we look that isolines, we spoke about how isolines are connected based on the same representation values are the same elevations in that region. So isolines as I said not criss-cross each other. Isolines are also called as contours that is what we have understood.

We have also seen how the isolines can be represented, then we look that the advantages and disadvantages of isolines. So we clearly understood that isolines representation the layer wise computation is extremely difficult and also be understood that isolines cannot be directly used instead it has to be either converted as a raster or converted into TIN model in order to represent it.

And then we look at accuracy, what are the 5 different ways of looking at accuracy, what are the things that you have to see, if you look at accuracy then we looked at how do we represent time, time becomes a very integral part when you are looking at certain aspects and certain aspects are involved in terms of representing any network. Then, we look that models for movable objects. So, these are those models based on networks.

We also looked at how network with only topological information cannot actually model the real world phenomena like the surface flow. But, if we include terrain the geometry with grid gridded values, then it can even model the movable objects which are on the surface. So with this we will end today's class. In the next class we would look at more further aspects of how we develop this models and how we interpret this models in today's context. Thank you very much, let us meet in the next class.