Introduction to Geographic Information Systems
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Lecture - 05
TIN data model and comparison with raster

Hello and welcome to this fifth lecture in the series of introduction to GIS. If you recall yesterday we have discussed various types of vector data, as well as various types of raster data and their comparisons. Advantages and disadvantages 1 more type of data which is handled in GIS is TIN that is triangulated irregular network. And the in this particular lecture we will be focusing mainly on this TIN data model and we will try to see the advantages and disadvantages in comparisons to raster data. TIN is also in previous lecture I have mentioned that TIN neither is vector nor raster, but in some literature you may find that they have put along with vector and some literature they have put along with raster.

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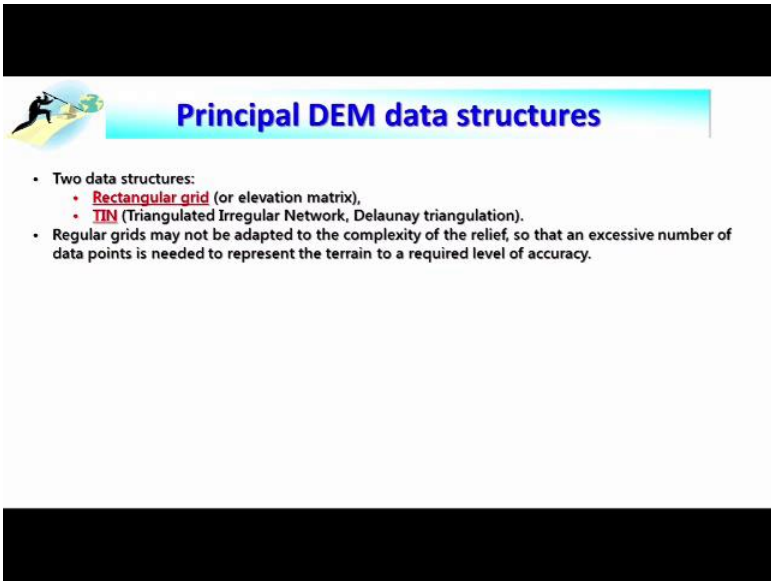

So, let us keep that as a completely separate and TIN you know that raster is having a rectangular grid or a square shape grid, but the unit is a there is a square all the time. In case of TIN it is a triangulated irregular network; that means, there are a series of triangles of different shape and sizes and this shape and size is decided based on a theorem or a concept which was given by Delaunay triangulation which we will discuss just little later.

So, sometimes what happens that they when terrain is having a load of undulation a natural terrain having load of undulation, like for example, Himalayan terrain it is having very high raggedness there suddenly you will find a hill and then the valleys ridges and valleys. Because of that your regular rectangular grid; that means, the raster cannot really represent the complete roughness of the terrain. Therefore, a different kind of model is required to represent such terrain conditions or a plane area like innovative plane which is alluvial plane, where you flat area where you can represent even using simple contours; that means, vectors using poly lines or even raster or with the TIN as well, but the same models cannot be applied. So, easily in case of a ragged terrain light Himalaya.

Contours if you see a 50,000 scaled to proceed in which even if contours are having hundred meter intervals they are so closed because the raggedness the changes in elevation a small horizontal distance is very high. Therefore, we need to have a different kind of model a data representation by which you can truly represent the terrain or near a natural conditions. So, the complexity of relief cannot be really represented by regular grid like raster data. So, this concept of terrain has come.

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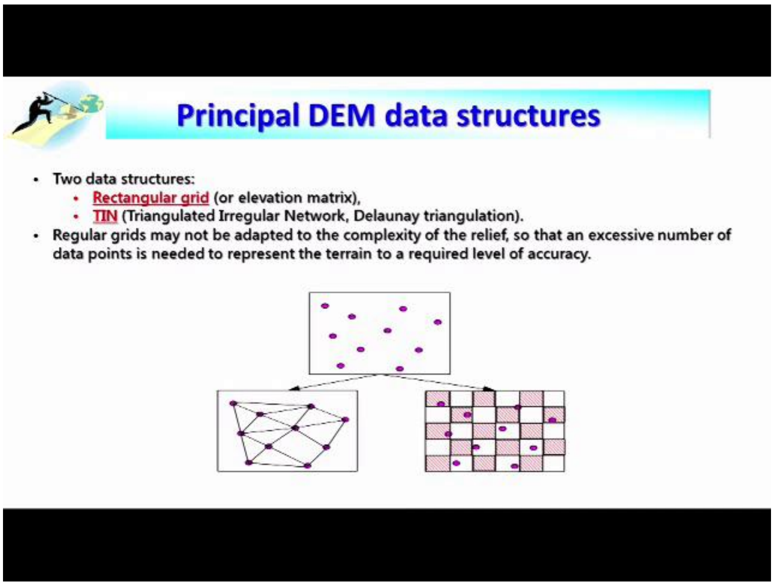

Now; obviously, each and every data model that there is a vector data raster data or TIN all are having their own, advantages and disadvantages. Here you can the initially you can also realize that if suppose there is a point data and which I want to this is a discreet, I want to make a continuous data. So, I can use as a regular date; that means, I can create through interpolation techniques, which we will discuss some time later in this course and you can create a grid using these points as observation points.

Same time using the same observation points you can also create a TIN model. Where you are seeing different shape and size triangles which are in a complete network and this network is irregular. But it is it is based on certain concept which we will discuss little just after this the other important thing that on there you do not have any observations that is the limitation in case of TIN, but in case of raster a between 2 observations interpolation will be done, but beyond an observation then extrapolation is done, and therefore, you achieve a completely rectangular or say square shape raster, but in case of TIN that kind of thing cannot be achieved.

So, let us look the definition that the surface representation, terrain surface like a Himalayan ragged terrain can be derived from irregularly spaced points and break line features.

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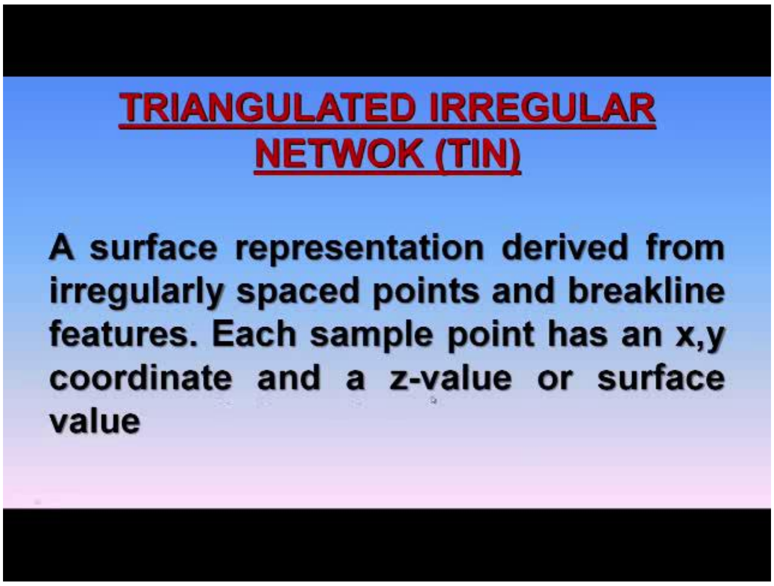

Each sample points have an x and y coordinate and then z value surface value. So, you are all you are having x, y, z together with this one. Now a as we see that a TIN represents surface a terrain surface.

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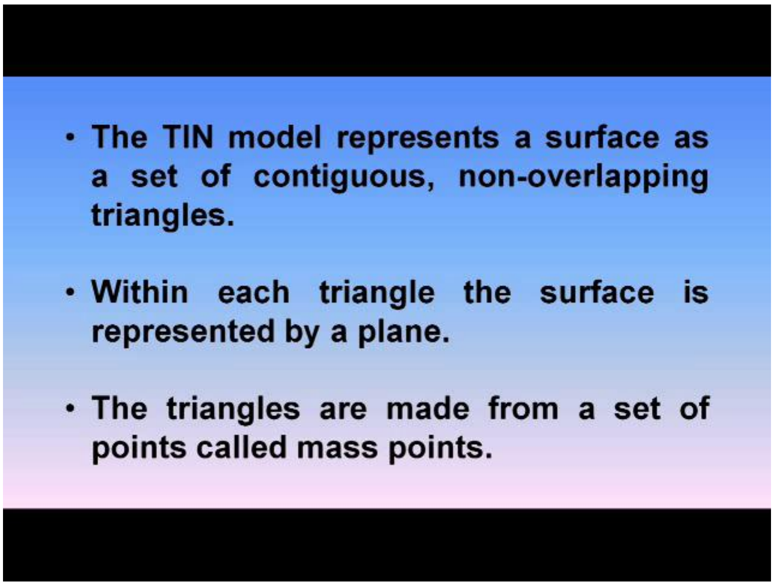

Which is a set of contiguous and non overlapping triangles, no triangles will overlap to another 1 wavering triangle this is a same condition almost in case of a raster data. But initially when these set light data or image data which is also a raster data when, it is started acquiring by the lend set 1 through the sensor which is MSS at that time, there were overlapping pixels; that means, overlapping cells of a grid and it was instead of saying pixel we use to call as Pixel, but latter on this problem in later senses what are resolved and now each pixel is representing unique area of the earth.

So, here in this case in case of TIN there is no overlapping triangles, each triangle is representing facet that we will see within each triangle the surface is represented by a plane and the triangles are made from a set of points called mass points. The input the same input that is the discreet data that is the point the simple vector entity can be used using interpolation to create a grid raster. Whereas, the same set of points discrete points can also be used to create a TIN surface.

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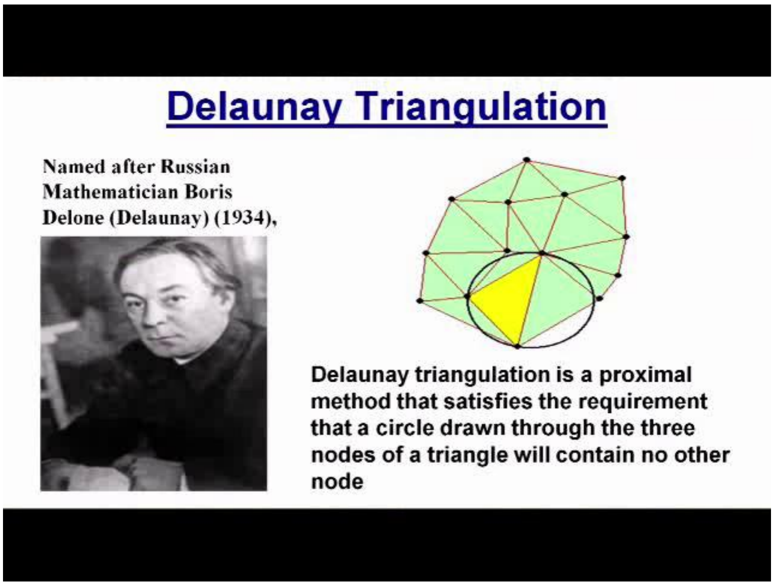

This is the bases of TIN, that the Delaunay, who was a mathematician; Russian Mathematician; Boris Delaunay in 1934, he gave the concept and which did the if a circle is drawn through 3 points then then it should a touch a these points, but no other points should fall in it. So, see that it sets it says that satisfy the requirement that is circle drawn through the 3 points, 3 nodes of a triangle will contain no other node.

So, this based on this algorithm, we keep we keep creating triangles till we reach to this condition and once this is satisfied then, that triangle for that particular area using three points is finalized and likewise for entire input points, a triangulated irregular network is created. So, this is the bases of that the when a circle is drawn through the 3 nodes here, on this example of this yellow color triangle then, within that triangle no other node will come. So, only three nodes can be there, node beyond if there would have been 1 more or 2 nodes than smaller sizes triangles will be prepared.

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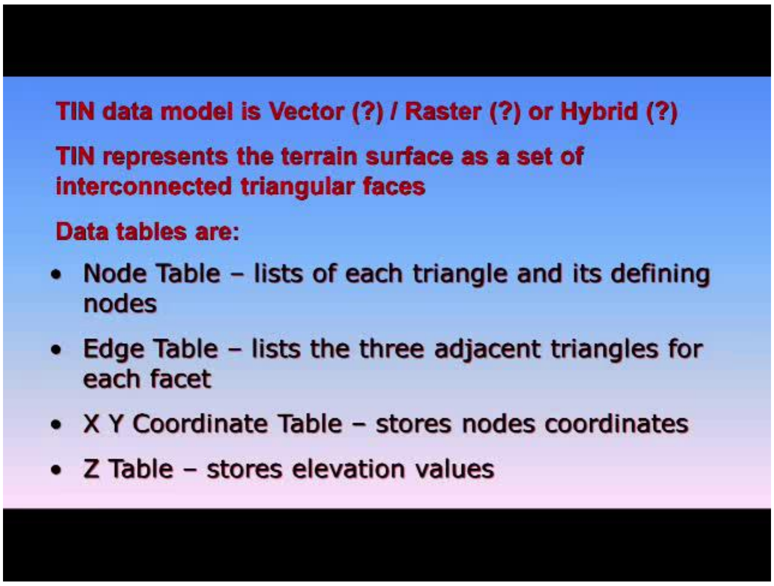

So, the TIN as mentioned neither vector nor raster or main would be, exactly hybrid model as well. So, TIN let us considered TIN as a complete separate kind of data representation model is especially suited for highly ragged terrain like Himalaya.

Now, TIN as you know that vector how a vector is stored in a system or vector is handled by computer is altogether different. Similarly raster or grids are handled biased on the matrix concept of mathematics. Whereas, the TIN again it is stored in tabular form which we will see for tables are created for each TIN 1 tail is called node table the other which is containing the list of each triangle in it is defining nodes we will see example very soon. Then we are having edge table edge table list of 3 adjacent triangles for each facet the neighborhood operation has also discuss in previous class that we have to be kept in that system GIS is, the 1 of the bases GIS is keeping information about neighborhood and x y coordinate table; that means, the coordinate have to be also stored of these points which have known to create the TIN and a which are node coordinates and z table which is the your hide value stored in case of elevation that becomes your z it may be some other value it no problem. So, z value will go in the z table.

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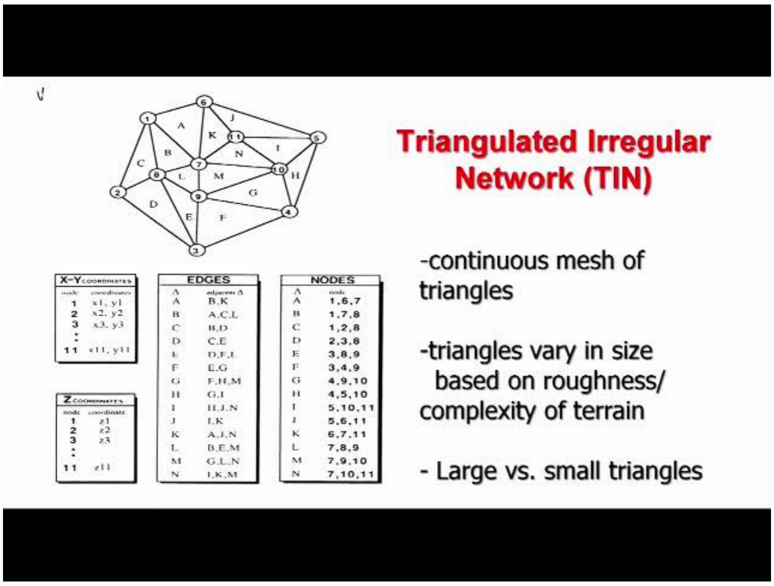

Let us see the real example, that there are nodes 1, 2, 3 and up to 11. So, there is a node table and that is storing the number of nodes which are making a particular triangle. So, if we take example of that triangle, A is made from node 1 6 and 7 node triangle, A is made from 1, 6, 7 and so on and so forth.

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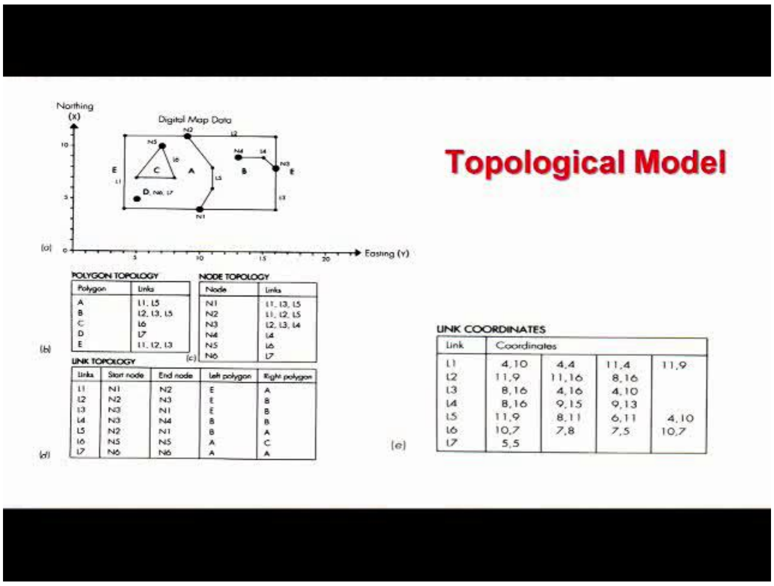

Similarly, the next table is the edge table which states the adjacent neighborhood operations. So, if we keep the same example of triangle then neighborhood triangles. Here b and k now important thing here is to note that outside the other side, the third side of triangle a no triangle exists and therefore no information can be stored. Now as mentioned earlier in case of raster then we use point data to create a raster surface through interpolation between 2 observations interpolation is done. Beyond 1 observation when we do not have another observation then extrapolation is done in case of TIN such things cannot happen.

So, that if the margins of your data extends of your data you do not have any other triangle because you do not have any observation. Otherwise, this cannot satisfy the condition given by Delaunay and did then x, y coordinates are also stored. So, say for node 1 then x 1, y 1 and likewise for all these in this example 11 nodes are there. So, all the data we are stored about their coordinates.

And then last 1 is the z coordinates that is maybe height or maybe some other consultation value. So, for node 1 z 1 node 2 z 2 and so on and so forth and there is no gap. So, it is a continuous mass of triangles vary in size based on roughness and complexity of terrain. See the size that is why irregular network triangulated irregular network. So, there are a unit here like in raster unit is it is square here the unit is triangle, but in raster the size of unit throughout a raster data is same if it is a 10 byte, it is representing say 10 meter white and 10 meter of ground, then throughout the data it is 10 meter by 10 meter, but in case of triangle the unit is of course, triangle but the size and shape of triangles keep varying and this variation will come because of the roughness or complexity of the terrain.

So, let me give you one more exam the same example again that if there is a Himalayan terrain then roughness is very high. Wherever rough is there a smaller triangles will be formed; whereas, in case of a flood terrain like (Refer Time: 13:08) plane, when roughness is very low is almost flat terrain then large triangles will be formed we will see through some real examples as well. So, this this picture will come very clear about large versus small triangles.

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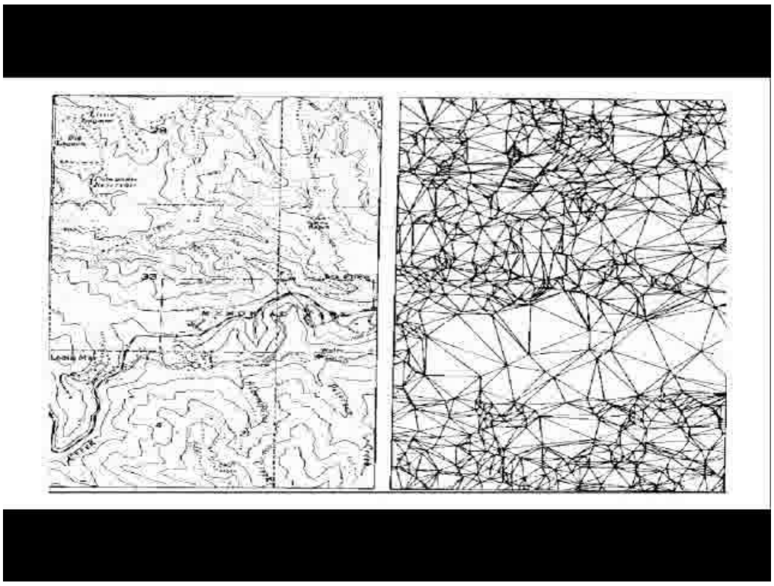

Let us take the real example, here the data for an area is represented through contours that are a discreet representation through your vector data, but if I have to represent the same terrain through a TIN model then this is how it will appear. And what you see that where wherever we are seeing less concentration of contours; that means, the contours line are a spars a at a little larger distance compared to other places then in this part you are seeing the large triangles. Whereas, there are contours are very close; that means, the surface roughness is very high raggedness is very high and therefore, a smaller a smaller triangles are made.

So, that is the beauty of the TIN that it is adoptable to surface roughness, comparison to raster it is not adoptable it is fixed for throughout that data. The size of a cell of a grid is fixed, but here the size of a triangle varies, including the shape of the triangle as you can see in this example.

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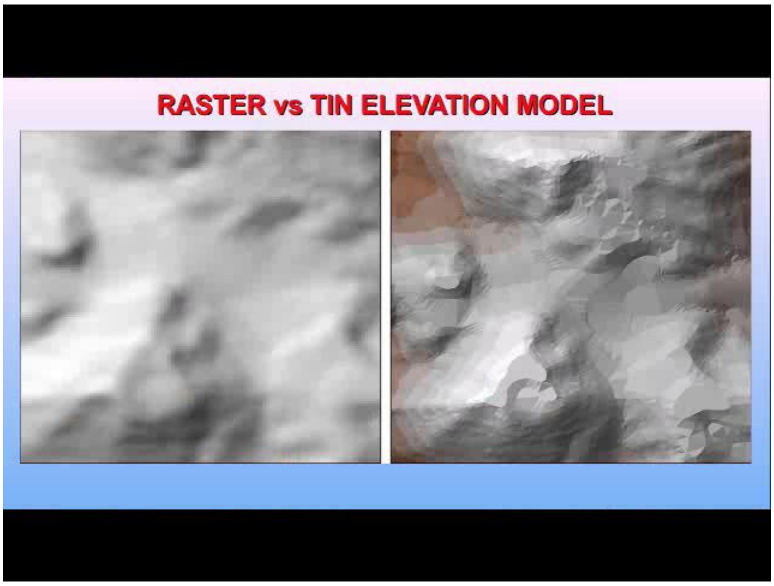

The another real example that using point data it is surface through interpolation techniques have been created and then we in order to make it little closer to the TIN shaded relief model has been also prepared for that. So, this is the representation at a particular resolution and this is the representation of the same terrain using the same point data set through TIN and this is how it looks. So, if you see your (Refer Time: 14:58) closely you would find that there are smaller a smaller large triangle depending on the surface roughness and the is a continuous mess and this is how the terrain is represented.

Now, there is another important thing is when you create TIN through using any GIS software we will see the 2 more byproducts are generated simultaneously. One is slope map and another 1 aspect map and third 1 you can also say about this shade relief model in case of raster each these products have to be created. So, in TIN this these are created automatic they looks better the TIN model looks better, but as I have mentioned if a in this particular example the edge problem is not shown, but in real situation the edge problem will always be there at the boundary you are having problems about the a data.

Now, as a let us let us looked the advantages and disadvantages associated with TIN model because it is adoptable and therefore, it can represent the complex relief. Relief or terrain roughness in a very nicely manner compared to even you vector data or raster data. Secondly, I have already mentioned that the terrain parameter like slop and aspect are calculated for each triangle and is stored as a tribute of the facet; that means the triangle and more detailed representation.

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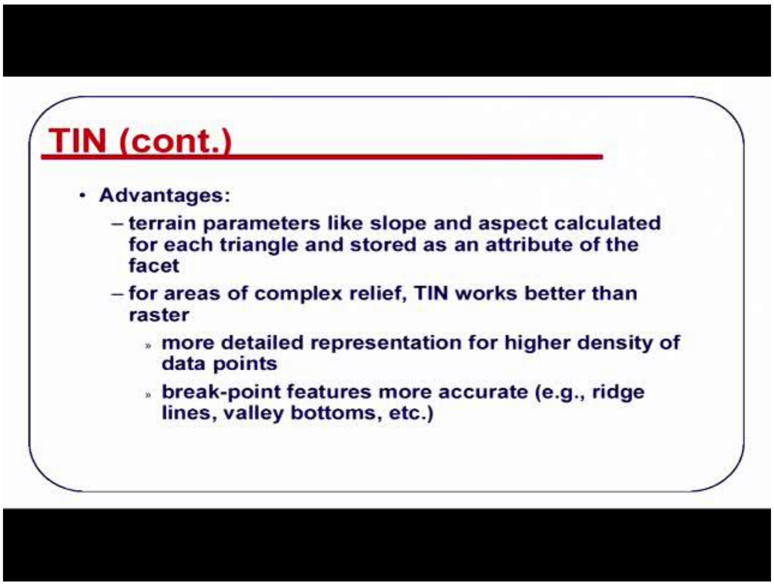

For higher density of data point if your observations are a lot for a small area that is the data points are very high then you can have much better representation well that kind of this kind of condition is also true in case of raster, but there the size of the cell will not change, here the size of the triangle and shape of the triangle will change. If there is variability in the observation; that means, there are a lot of changes in a small area or surface roughness can be represented nicely.

Another point is the break point features more accurate; that means, sometimes you are having ridges or valleys which are the sharp change, elevation changes features and these 2 can be represented in a much better fashion using TIN data model rather than raster.

Now, disadvantages; one disadvantage is about that the edge problem or boundary problem I have I have already discuss.

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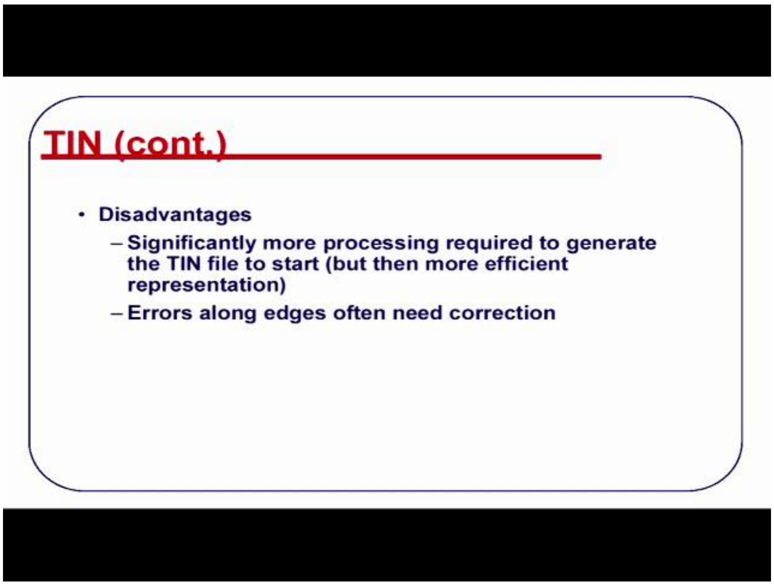

So, it is it takes more time for processing to generate TIN file. So, if you take the same set of points and a create raster leaving a one of that valuable interpolation technique you may not take that much time as creating TIN. So, TIN takes more time because a lot many things have to be calculated and organized in case of TIN and as I have already mentioned that errors along the edges often need correction this this problem is a sometimes later on in GIS operations it becomes little difficult or big. So, one has to decide whether he would he is with whatever the TIN is giving or if it is on the edges if it there is a problem then you will have difficulties with the TIN.

Now, the 2 more things I would like to discuss here, like a in case of raster you can extract raster, you can extract to make a subset of raster, but in case of TIN the clip or subset cannot be achieved.

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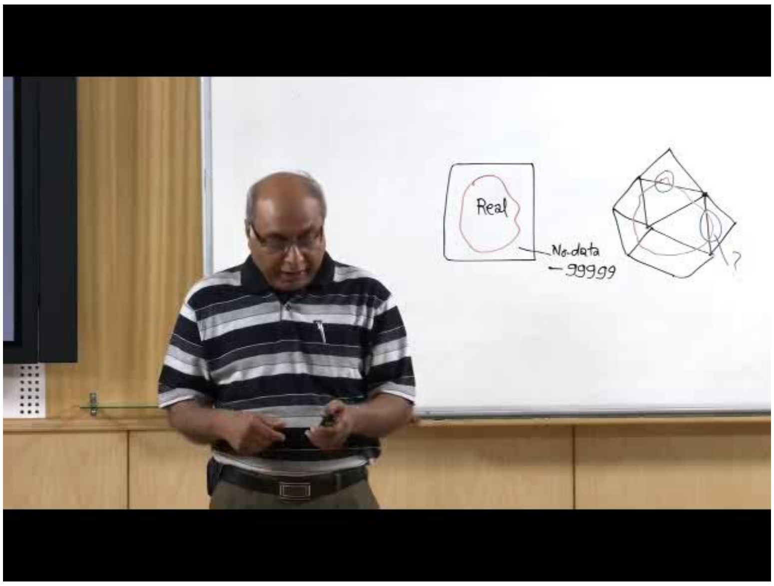

For example, if you are having a raster data like this and I want to extract a part of this raster say which I believe this polygon, in it is very easy in GIS operation that I can extract this raster, but remember fundamentally what I have said about raster that raster will store it is data in the computer either in rectangular form or square shape.

So, how it will do in this case, very simple once I when I extract this 1 it will keep the real data for this, real data, but here for outside it will keep the no data and no data. That does not mean GO value no data is some value which will be declared to the computer that, this is my no data value. For example, it can be say a value likes minus 99999. Now why this kind of values because most of the time the digital elevation in case of digital elevation models we know that we cannot have on any n surface of the earth a point which is having such a depth or some plus values. So, therefore, it is declared to the system that this is no data value and; that means, whenever I am doing any processing on this set data set then, I do not want to include the outside area I want to include area which I have extracted.

Now, if I am having a TIN model as we have been discussing. So, in in the in case of TIN there would be edges, there would be edges on in case of TIN and these I cannot use any model, I cannot use any extraction tool to cut here. Because what would happen think, what would happen in case of these areas, similarly the areas which are going in another trend because fundamentally the unit here has to be a triangle and that is why a jokingly it is said that there is no scissor which can cut this TIN. The TIN in the GIS whereas, the scissor exits software tools exists to cut a raster, but software tools do not exists because fundamentally they are not supported to cut it in or extract a subset of the TIN. This is another limitation of a TIN and all this limitation is coming just because of the errors along the edges errors the boundary problem with the TIN is quite a bit sometimes.

Another thing is that a lot of analytical tools which we will be seeing in later lectures, that they assume that the data input data are coming in form of raster. Now if I have created a TIN after sometime I would realize that this TIN is giving problem to me during my advance analysis. So, therefore, there are tools are available to convert a TIN into raster. Now question is ultimately if I have to only convert the TIN to raster then why I would make in between TIN. So, that is that depends on your project requirements, if your projects requires only up to the TIN and you can deliver the things as per derived using the TIN is fine, but if you want to use that TIN further along with the raster data then you have to convert it into raster. So, this is another limitation with the TIN.

Now, we have already completed sort of thing, but for comprehensiveness and completeness we will just go 1 by 1.

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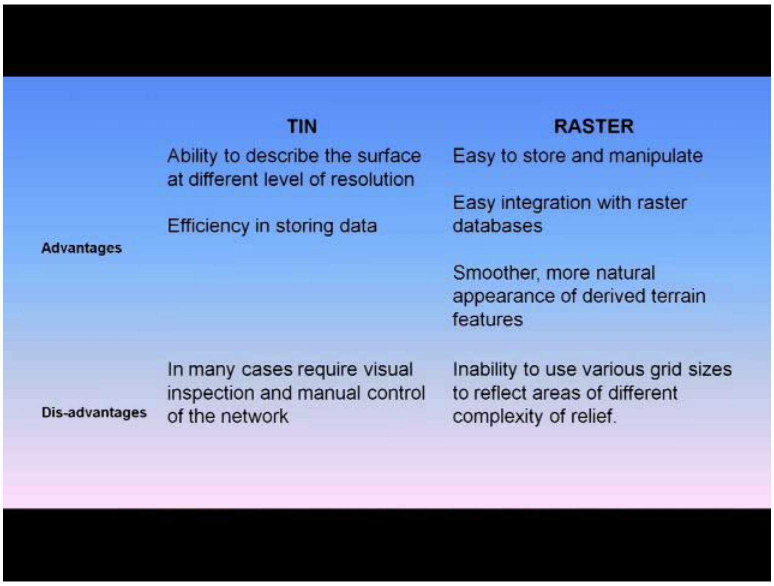

That the advantage with TIN is ability to describe surface at a different level of resolution, resolution is not fixed here because the size of the triangle is not fixed and it is a there is no redundancy in case of TIN, but in case of raster that it is easy to easy to store and manipulate because concept wise raster is the most easy data format even easier than then your vector and it is easy integration with other raster data sets for example, satellite images which are the very big source of data input in modern days GIS and then smoother more natural appearance of drive terrain features looks in case of raster may not be in case of TIN.

In many cases disadvantages many cases requires visual inspection and manual control of the network, sometimes you get some problems and then these problems cannot be automatically solved. So, manual intervention human interventions are required at the state, but in in case of raster such problem may not come in ability use various grid sizes to reflect. That means if I want to see that high complexity of relief, I have to adopt for higher and higher space of resolution. So, these are the advantages and disadvantages associated with TIN and raster.

Let me take few more examples and get comparison sort of thing. That is if I do not use any break lines then the data can be represented in TIN in this form. Whereas, in d e m is the raster it is in this form, but when I use the soft break lines then I am I will represent the TIN like this.

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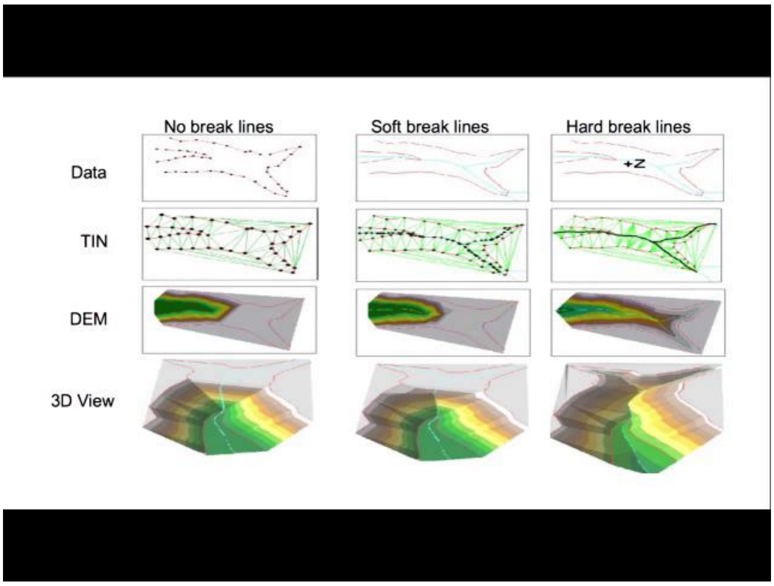

My terrain like this anyway this is a three d view for all three types of data generation. And the third example is when I am using hard break lines I will elaborate on this about the hard break lines, soft break lines and no break lines. Break lines are can be ridges can be valleys or can be geologically structures. So, when these structures are very prominent and having complete influence or control over the terrain, then we will go for hard break line options while creating a TIN or creating a raster. When we are not sure that how much influence they will have in they might have influence may not have influence that kind of thing.

Then we go for soft break lines generally in the terrain which is not ragged as like Himalaya. So, if it is terrain is smoothly a smooth terrain undulations are there where very smooth then we will not we will not go for hard break lines options, we should go for soft break lines option and when we do not know we do not have any input about the break lines, then either you go and collect it, if it is not possible then you have live with without no break lines.

And as you can see that the prominence because of the choosing hard break line, that terrain looks altogether different that the terrain without break lines. So, this has to be these are the options while creating TIN or raster about the break lines, but the knowledge of the break line has to their 1 and this input will come as a vector layer as a vector poly line layer.

So, another very TIN has got a wide applications almost all now a days is animations, which we are seeing on internet of through computer games another things. They all are using this TIN data model and then top of that they are burping with some color image or pattern.

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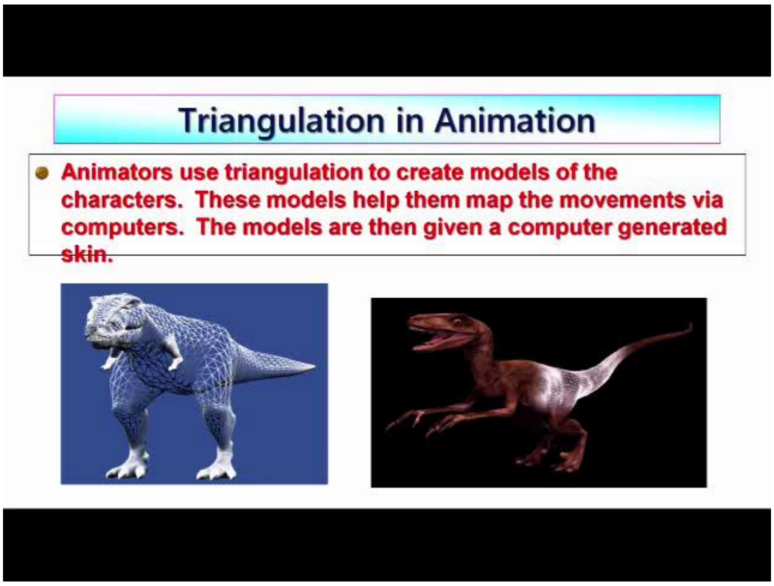

So, digital elevation model is one of the good applications of TIN which represents your terrain and it can be used for few more analysis like cut and fill in other things surface reconstructions especially for three dimensional.

A surface, it has got in application in industries and apart from terrain it has got a producing animation movies and other thing I will show you some examples. Like here, if I have to represent animal than I can use a TIN represent a 3D surface you instead, if I for raster representation I may not represent died animals. So, accurately as using TIN that is why most of the animations people have adopted TIN rather than raster.

And a animators use triangulations to create a model of correctors as you can see for this dinosaurs and these models help them the map the movements by a computers because, in the when these animated animals moves it is much easier to control through these TIN models rather than any other model. So, that is why it is preferred by animators to use TIN and once you fill these triangles with some color or shade or a skin color roughness than these animals looks real, real one. So, this part is not as completed the rest is completed. So, it looks mush real one so.

Thank you very much for this.