An Introduction to Surfaces and Terrains, Part 1

Transcript

Colin: Hello and welcome to ESRI Instructional Series podcast. This broadcast is entitled *An Introduction to Surfaces and Terrains*. I'm Colin Childs from Educational Services at ESRI in Redlands, California, and today I'm joined by Clayton Crawford, product manager on the ArcGIS 3D Analyst team.

Clayton is going to help us learn more about surface terrains and terrain datasets during this broadcast. Today, I'll be asking Clayton to tell us more about how we store surfaces and manage surface data in ArcGIS. This discussion is tailored to users of the 3D Analyst product who have to deal with large amounts of data representing surface information, and who want to learn more about how to store and maintain this data efficiently in ArcGIS.

So Clayton, let's get started with the discussion, and I'm going to ask you to briefly tell us what do we define as a surface? What do we mean by a surface?

Clayton: Well, a surface, a functional surface, is a field of values that vary continuously over x,y space. So a value of (it might be an attribute of something that you're trying to measure; maybe it's the height topography, depth of imagery, or a concentration of chemical), these values can be unique at a given x,y location, and there're infinite potential numbers of measurements that could be taken within that field. But we typically, for the sake of practicality, just take a sample of those measurements to use to define the surface, and then use some function to interpolate values between the samples.

Colin: Okay. Well, that's really interesting. So tell me how we traditionally stored and managed surfaces in the ArcGIS product. I guess there are a lot of other products that do the same kind of thing, so what have we traditionally to store surfaces and deal with them?

Clayton: There are primarily two different types of surface models that have been used. There're raster-based and TIN-based surface models. The rasters use a regular-spaced measure or lattice of points to represent the surface, and so they are regularly spaced x,y samples. We don't actually (since they're regularly based), we don't need to record a separate x,y coordinate for each value (that's kind of implicit). Although, we have a separate Z that's recorded for each point (and for practical purposes, that very closely mimics an image format), so we can store them just like any other image format. And then, TINs are vector-based surface models, where we take mass points, individual point measurements, or break line data in the vertices of those and connect to those into non-overlapping triangle facets that define a piece-wise definition of a surface.

Colin: Okay, so raster and triangulated-irregular networks. So tell me, do these different surface storage methods have limitations we're aware of?

Clayton: Well, our TIN implementation has a practical limit of 15 to 20 million points in an individual particular TIN model. That's because we want to load the entire model into memory for efficiency's sake, and we have a 2 GB per process limit under Windows Win32, and so that provides some constraint there for us.

Colin: Ah, and I guess these newer, bigger data sets, of course, are problematic when you're using the standard TIN, right?

Clayton: Right. Uh, that limit usually gave us plenty of space for traditional kinds of photogrammetric type TINs that people have been building for many years, but with newer stuff, we're far exceeding that requirement and many more measurements are needed.

Colin: Okay. And rasters? What sort of issues might there be with raster services?

Clayton: Well, I think probably the biggest issues with rasters, when it comes to dealing with surfaces, is that they're derivative, and if you are needing to manage surface data over time and update surface information over time (that you really need to), you can't just update the raster very easily with that new information. You need to go back to the source data and reconstruct the raster from scratch, so you don't have some weird artifact in the rasters. So their weakness is somewhat that they're derivative, and the source measurement data is not represented in the raster in any way like the original x,y source measurement data has disappeared in the sample that represents the raster.

Colin: All right. So there are obvious limitations to the traditional TIN and raster. So what's new, and what new ideas have you come up with respect to dealing with large amounts of data and surfaces? Do you want to tell us a little bit more about the concept of a terrain, which I understand is the newer way to deal with large surfaces?

Clayton: Yes, yes. Well, because of the limitations on TINs and rasters, we really needed to come up with a solution to overcome those; the size limitation on the measurements in TINs is a big thing. And also, needing to have the source measurement data and accuracy available to us was important, so we wanted something like a TIN, but that would overcome those source limitations, so the terrain concept (the terrain data set was born from that), and so they use a TIN-like structure for representing surfaces, but they do so in a unique way that can efficiently handle large quantities of data at different scales. We use different quantities of measurements to come over performance limits and whatnot.

Colin: All right. So terrains are the new thing we need to know a little bit more about, so what are some typical applications and potential applications for terrains?

Clayton: Well, they're really just the same as potential applications for TINs and rasters. Bathymetric, topographic mapping applications such as flood plain mapping, watershed delineation, hydrologic modeling; dredging is important for navigational waterways, or measurements are taken on water and deposits of silt and whatnot. It's very expensive to go through those operations of the dredging, similar to that in the construction domain, cut/fill applications estimating where earth needs to be removed or added for construction projects. There's also transportation and emergency management applications; visibility, line-of-sight things are very common in the world of planning and communications to ensure that the communication devices can communicate with one another or that a certain building that's being added somewhere can or cannot be seen depending on the desirability (for example), so the terrain applications follow along the traditional lines of just surface modeling applications.

Colin: Right, there certainly seems to be a myriad of applications out there. So what are some of the typical data sources that we would use to create a terrain?

Clayton: The most common would be photogrammetric data sources, made from stereo imagery collected from airplanes and lidar, laser-based sensing devices, and sonar (modern version of that being the multi-beam sonar).

Colin: Right. Guess a lot of people listening here today will be aware of lidar and lidar data and the potentially large amounts of data that you have with those. So tell me, were there some motivating forces driving the development of the terrain and the terrain data set which came out of the terrain development?

Clayton: Yes. Well, lidar really, was the prime driving force behind terrain. North Carolina was the first statewide lidar collection project in the United States, and you can imagine a state-wide lidar collection project. They produced billions of points. They needed some way to manage that data, and so we wanted to develop something that could handle projects and data produced in that kind of magnitude, so scalability is a huge thing.

Colin: I guess another motivating factor was being able to keep the original data from which the surface would be created, and being able to update that data and maintain it. And if you had newer measurements to include those, and so on as well, so that would probably be part of keeping the data set up-to-date and would be a good motivating factor as well.

Clayton: Right. For some applications, end users, they're just maybe needing to use the end surface that's constructed for their analysis, and don't care so much about the source data, but people that are responsible for constructing those data sources are very concerned about the management of that source data. Source data is golden in that sense, and if edits need to be made, quality assurance improvements, updates to data over time, we really need to be attacking the source measurements for that. And so the terrain lives along with the source measurement data from which it's derived, and it's aware of any changes made to the source measurement data, and so they know when they need to be updated and whatnot, so there's this integration between the source data and the terrain that's a very important link that's maintained.

Colin: So you've told us already that the terrain is very different from rasters and TINs, and as I understand it, the terrain consists of feature classes that participate within the terrain itself, and you can specify how those feature classes and features are used. I was wondering if you could tell us a little bit more about the data itself that is used to create a terrain dataset.

Clayton: The data is stored in feature classes, inside a feature dataset, inside a geodatabase. These can be point, line, and polygon-based features; and the feature classes participate in a terrain not unlike how feature classes participate in a topology, so you define a terrain by indicating which feature classes participate in the terrain, and then how those feature classes participate. So for points, you can say they participate as mass points in a triangulation; they get added as notes in the triangulation. Line data can be added as break lines, where we have distinct breaks in slope that occurs across that line data. The polygons can be used in a few different ways (for example, to delineate the interpolation zone or the data area). If the data doesn't have a convex boundary, we want to accurately define that boundary.

Colin: That's the hull, right?

Clayton: Right. A convex hull-shape, which is, well, you can imagine if you had a rubber band that gets stretched tightly around, say, a point set, what the shape of that rubber band would be, it's kind of the convex shape. But typically, data isn't collected in that shape, like the shape of a county boundary, or the township boundary doesn't have that nice shape to it, so we want to be able to control that with clip polygons. Also, there are interior areas often that, for which samples could not be collected for some reason, say in dense forests…

Colin: A lake, maybe.

Clayton: Inside water bodies. Yeah, lidar returns are not reliable over water, so where we do not want interpolation to occur for whatever reason, we can have polygons that we incorporate as erased polygons in the terrain; so they can be used that way. Also, replace polygons, if for a water body you do want interpolations to occur and you know what the height of the water body is, replaced polygons can be used to assign a constant height within the polygon.

Colin: Okay. Gives us a very good idea of the data that you put in. I think we'll stop at this point and we'll continue with another podcast at a later time. So everybody fulfill the resources, please check out the ArcGIS Desktop Help topics on terrain surfaces and terrain datasets. Also, remember to check out your product pages and the software tutorials. Our next podcast in the series is going to delve deeper into terrain datasets and explore some best practices.

Thank you for tuning into the session of our ESRI Instructional Series podcast. Stay tuned for future broadcasts.

