

How Graph Theory and Computational Geometry form the backbone of GIS

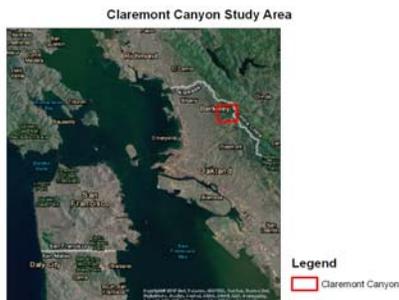
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Abstract

For the first 7 weeks of this semester, I explored concepts in graph theory. This laid the foundation for the second 7 weeks of the semester. I looked into graph theory and computational geometry, a topic that my father John Radke has a PHD in. He is a professor of GIS at University of California, Berkeley and he worked with me to explore these topics through weekly readings and exercises in ArcGIS.

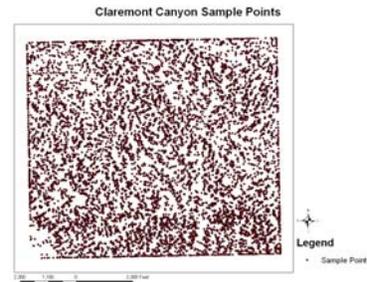
Introduction

Throughout the readings, the graph of the Delaunay Triangulation played a big role in computation time. I will discuss this further in the methodology. One of these weekly readings focused on a Triangulated Irregular Network (TIN). Using a TIN, one can create an accurate surface model from a set of sample points, each with a given elevation associated with them. Creating models that accurately depict real life is important when it comes to running analysis. For sake of space and time, I will focus on an exercise using a TIN and show how powerful the graph of the Delaunay Triangulation can be when it comes to representing the real world in a model. The map below is just so you can get an idea of the study area of this example. Keep in mind, this can be reproduced anywhere with similar data.

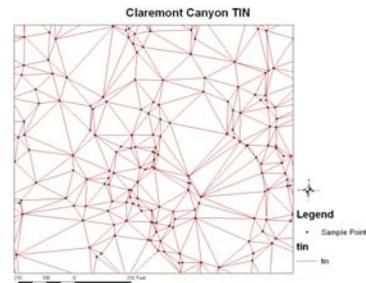


Applications

For this assignment, I downloaded data off of the Berkeley server. The data included a set of points from the Claremont Canyon, an area in the Berkeley Hills.



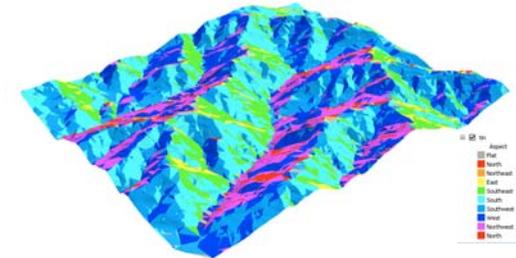
Each of these points has an elevation associated with them. The first step is to create the TIN. There is a tool in the 3D analysis toolbox called *Create TIN* that does this. When creating the TIN, I set the height field to the elevation of each point. After setting the symbology to what I want, it looked like the image below. This is zoomed in so the complexity of the triangulation can be seen.



After I created the TIN, I moved to ArcScene. Once I added the TIN to ArcScene, I can display it in 3D by setting its base height. The original TIN is seen below.



Now that we have an accurate representation of what the surface of the earth is doing in this region, we can run some analysis. We can display the TIN showing its Aspect Map. This is a map that determines which direction each facet of the TIN is facing, and colors it accordingly. Below you can see an Aspect Map of the region.



Another cool feature of this surface model is the ability to drape other shapefiles on top of it, to create an even more accurate virtual reality. Part of the data I downloaded included houses and roads. Once I added them to ArcScene, I could set their base heights to the TIN and they would appear to be draped over the surface. Taking it one step further, I used the extrusion options for the houses, to give them a real sense of being built up from the surface, like they would be in reality. You can also drape aerial imagery over this surface to create an even more realistic model.



Conclusion

The Delaunay Triangulation, or TIN, is an extremely powerful graph when it comes to graph theory and computational geometry and their applications in GIS. This poster just scratches the surface. It also has many applications in Network Analysis as well as many of its underlying graphs. But where does it come from? As it turns out, the Theissou Polygon graph, or Voronoi Diagram, is the geometric dual of the Delaunay Triangulation. This means that they are opposites of each other. That is a discussion for another poster, but this idea is what allows the Delaunay Triangulation to be calculated at such speed by the algorithm that we, as ArcUsers, never see. Without this fact, our tools in ArcToolbox would run at much much slower speeds.