Editing DEM Files to Represent Overhanging Structures and Arches

wheaton college massachusetts

Hannah Lord '22 Advisor - Michael Gousie

INTRODUCTION

GIS platforms such as Google Earth combine raterized elevation data and satellite imagery to visualize the Earth's terrain and natural landscape. The absence of satellite imagery yields windowless cliffs or hills where overhanging structures such as natural arches, bridges, caves, and cliffs are located.

The purpose of this research is to manipulate ASCII DEM files to represent these overhanging structures.

Delicate Arch, Arches National Park UT
Photo from usgs.com

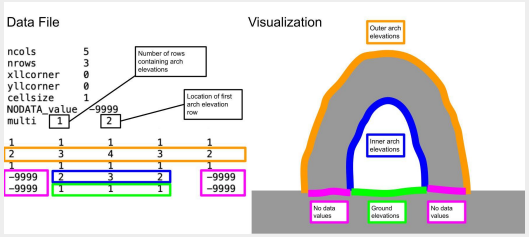
DEM FILES

Digital elevation models (DEMs) : ASCII text files that contain a header that specifies the file size, coordinates, resolution, and a no-data value, followed by a matrix of elevation values. Each elevation's row and column number corresponds to an xy coordinate on the planar terrain.

The DEM file header was edited to include a "multi" line for arch functionality.

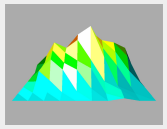
- **first value** : specifies the number of rows containing outer arch elevations
- **second value** : specifies the first row that contains these elevations.

The specified number of rows of inner arch and base elevations are at the end of the file. Cells where elevation values do not exist are set to the no data value.

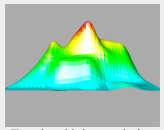


IMPLEMENTATION

This program was developed in C++ using the OpenGL library. The resolution of the original file was increased by interpolating between real data points using a Catmull Rom spline.

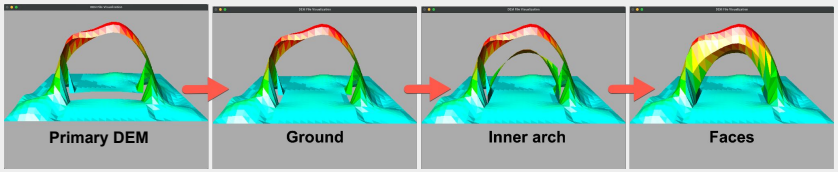


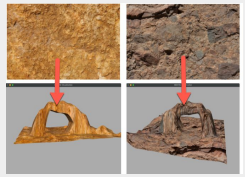
Terrain without interpolation



Terrain with interpolation

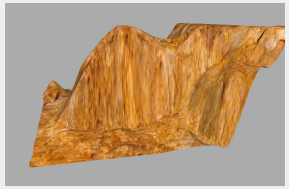
The arch structure was triangulated in four parts, as visualized below. The initial terrain was modelled using an algorithm to detect the location of the window and triangulate around it. The faces of the arch were interpolated in the z direction to avoid a completely flat face.



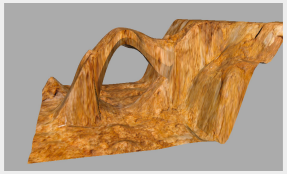


A rock texture was then mapped to the triangulated surface. Each x/z coordinate was divided by the columns/rows of the file to obtain the texture coordinate. Since the ground and top of the terrain share x,z values, the same portion of the image is applied to those areas.

OUTPUT



Normal DEM file - the arch structure is a steep, windowless cliff.



Edited DEM file with additional arch data - the window is visible.

CONCLUSIONS & FUTURE WORK

This current edited DEM file format and associated implementation code can successfully render an arch structure that lands on a horizontal axis. Test data has been developed, but real data has yet to be collected.

Future research will involve:

- Developing an algorithm to detect the direction of the structure and the location of the window, to accommodate more realistic occurrences
- Creating a complex data structure to store vertex normals
- Further testing and use of real data

REFERENCES

- Digital Elevation Model (DEM) Formats https://library.carleton.ca/guides/help/dem-formats
- Gousie, M.B. and Franklin, W.R.Augmenting Grid-Based Contours to Improve Thin Plate DEM Generation. Photogrammetric Engineering & Remote Sensing 71, 1 (2005), pp. 69-79.
- Rose, D, Interpolation. March, 2017 , https://danceswithcode.net/engineeringnotes/interpolation/interpolation.html
- United States Geological Survey https://www.usgs.gov/