**Lab Report 2.2**

Title: Creating a cost surface model.

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**Project Repository:**<https://github.com/tjjohnson1415/GIS5571>

**Time Spent:** 17 hours

**Abstract**

Land cover classification and a digital elevation model were used to create a cost surface to help Dory determine the best path between her home and her favorite fly-fishing spot in Whitewater State Park. She does not want to cross water bodies or farm fields and would prefer to walk the path with the most gradual slope. These rasters are given weights and combined into a cost surface which is used to calculate the optimal path. Varying the weights will cause the optimal path to change.

**Problem Statement**

Dory is looking to find the optimal walking path between her home and her favorite fly-fishing spot in Whitewater State Park. Dory would like to avoid farm fields because they can be muddy and would also prefer to avoid water bodies. Both layers can be extracted from a map of land cover classification. Dory would also like to avoid steep hills if possible. A DEM can be used to calculate the slope in each pixel of a raster. These three criteria can be combined using map algebra to create a cost surface and determine the best path.

Table 1: Data used in this lab.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **#** | **Requirement** | **Defined As** | **(Spatial) Data** | **Attribute Data** | **Dataset** | **Preparation** |
| 1 | Data including water bodies and farm fields | Land cover classification | Raster | Land cover | [Minnesota Geospatial Commons](https://gisdata.mn.gov/dataset/biota-landcover-nlcd-mn-2019) |  |
| 2 | DEM | Minnesota 30 m DEM | Raster | Elevation | [Minnesota Geospatial Commons](https://gisdata.mn.gov/dataset/elev-30m-digital-elevation-model) |  |
| 3 | Start and End Point | Endpoints | Point Geometry |  | Self-Created |  |

**Input Data**

The data used for this lab are a 2019 National Land Cover Database land cover map retrieved from the Minnesota Geospatial Commons, a USGS 30-meter digital elevation model retrieved from the Minnesota Geospatial Commons, and a self-created dataset containing the beginning and ending points that we would like to calculate the optimal route between.

Table 2: Data

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Title** | **Purpose in Analysis** | **Link to Source** |
| 1 | Land Cover | Create Boolean rasters of water bodies and agricultural fields | [[Minnesota Geospatial Commons](https://gisdata.mn.gov/dataset/biota-landcover-nlcd-mn-2019)s](https://gisdata.mn.gov/dataset/trans-roads-mndot-tis) |
| 2 | DEM | Calculate slope to find paths with most gradual slope | [Minnesota Geospatial Commons](https://gisdata.mn.gov/dataset/elev-30m-digital-elevation-model) |
| 3 | Endpoints | Define the start and end points of the optimal path | Self-Created |

**Methods**

Figure 1 shows the data flow diagram for determining the optimal path between the endpoints. The land cover raster is downloaded from the Minnesota Geospatial Commons and unzipped. The raster is clipped to the area of interest. Boolean rasters are created by defining which land classes will be given the value of 1 and which will be given a value of 0. Rasters of agricultural fields and water features were created. The DEM raster is downloaded from the Minnesota Geospatial Commons and unzipped. From the DEM, a slope raster is calculated and clipped to the area of interest. The clipped slope raster is normalized onto a 0 to 1 scale. The three rasters (agriculture, water, and slope) are combined using the raster calculator to create a cost surface. The cost surface is used with the endpoints dataset to determine the optimal route between the two points.

**A diagram of a company

Description automatically generated**

Figure 1: Data flow diagram.

**Results**

**A map of a land

Description automatically generated**Figure 2 shows an example of a cost surface developed by the model. The red dots represent the endpoints of the path Dory takes. Dark pixels are those with little cost associated with crossing, while white pixels are more expensive. Because Dory does not want to cross farm fields, they appear white. Because Dory would prefer more gradual slopes, the steep hills appear brighter than the flat ground of roads or the dry river plain.

Figure 3 shows some of the optimal paths developed by the model. Using different weighting schemes will create different optimal paths, so there are some variations in the optimal route. The background is the slope raster, with brighter being steeper.

**Results Verification**

The results can be verified by looking at the individual rasters that combined to form the cost surface and making sure that the optimal routes do not cross areas that they shouldn’t. Figure 4 shows the optimal routes overlayed on the water raster, the agriculture raster, and the slope raster. The optimal routes avoid all water and agricultural areas, except maybe cutting across a few pixels on corners or when necessary. The paths generally go over flat terrain, but they must go across some steeper slopes to reach the end point.

*A map of a mountain range

Description automatically generated*

Figure 2: Optimal paths.

A map of a road

Description automatically generatedA map of a city

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Figure 3: Optimal paths overlayed on the individual layers that made up the cost surface. From left to right: water, agriculture, slope.

**Discussion and Conclusion**

The optimal path for Dory to take is dependent on the weights given to each raster when developing the cost surface. Giving more weight to the agriculture raster, for example, will make the model less likely to path Dory through a farm field, because it will be less expensive to walk around it rather than through it. Because of this, Dory’s preferences for what she is or is not willing to walk through can greatly impact what the best route is and how long that best route is.

This lab got me to think about the implications of different weighting schemes and the relationship between cost and raster value. My analysis assumes there is a linear relationship between slope and the cost to traverse that pixel. It probably makes more sense to bin different ranges of slopes with increasing costs. It should be more expensive to cross steep slopes than a linear relationship allows for.

**Self-score**

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Description** | **Points Possible** | **Score** |
| **Structural Elements** | All elements of a lab report are included **(2 points each)**:  Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams, Results, Results Verification, Discussion and Conclusion, References in common format, Self-score | 28 | **26** |
| **Clarity of Content** | Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level **(12 points)**. There is a clear connection from data to results to discussion and conclusion **(12 points)**. | 24 | **24** |
| **Reproducibility** | Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified. | 28 | **26** |
| **Verification** | Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated **(10 points)**, the method of comparison is clearly stated **(5 points)**, and the result of verification is clearly stated **(5 points)**. | 20 | **20** |
|  |  | 100 | **96** |