**Lab Report 3.1**

Title: Comparing weighting approaches to generating cost surfaces.

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

**Time Spent:** 2 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. The weights associated with each criterion will affect the generated cost surface and therefore the optimal path. Three weighting schemes will be compared.

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. Cost surfaces were created using three different weighting schemes. The cost surfaces are used with the endpoints dataset to determine the optimal route between the two points.

**A diagram of a company

Description automatically generated**

varying weights

Figure 1: Data flow diagram.

**Results**

**A map of a land

Description automatically generated**

Figure 2: Cost surface for equal weighting of slope, water, and agricultural areas.

**A map of a land

Description automatically generated with medium confidence**

Figure 3: Cost surface for water weighted 1, slope weighted 2, and agriculture weighted 6.

A map of a river

Description automatically generated

Figure 4: Cost surface for agriculture weighted 1, slope weighted 2, and water weighted 6.

Figures 2 through 4 show cost surfaces generated by different weighting schemes, where white pixels represent areas with a higher cost. Figure 2 shows a weighting scheme where slope, agriculture, and water are all given equal weights. This makes it so that both agriculture and water are avoided as much as possible. Figure 3 shows a weighting scheme where agriculture is given a much higher weight than the other components. This makes it so that the cost associated with crossing farm fields is very high and makes it more likely for Dory to be routed through water. Figure 4 shows a weighting scheme where water is given a much higher weight than the other components. This makes it so the cost associated with crossing bodies of water is very high and makes it more likely for Dory to be routed through agricultural fields.

**Results Verification**

The results are verified by comparing the cost surfaces to landcover classifications. In the case of equal weights, both agriculture and water are expensive to cross, as is expected. When agriculture is given a higher weight, the cost surface has agricultural fields as expensive to cross, while water pixels are not. When water is given a higher weight, the cost surface has water bodies as expensive to cross while agricultural fields are not.

A map of a mountain range

Description automatically generated

Figure 5: Optimal paths for each cost surface. The red line represents the optimal path for equal weights. The purple line represents the path for when agriculture is given a higher weight. The green line represents the path for when water is given a higher weight.

**Discussion and Conclusion**

Figure 5 shows the optimal paths associated with each weighting scheme. The paths are quite similar despite the varied weights. Making the differences in weights more severe or adding additional parameters that influence the cost surface would likely produce more different optimal paths. Making one of the weights 0 would also have a greater effect on the optimal path.

**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** |