Lab 3 Report

Title: Using three different weighting approaches to determine optimal paths between two points using Cost surface Raster
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Project Repository: https://github.com/Zain1443/GIS5571.git
Google Drive Link:
Time Spent: 16 hours

Part 01

Abstract

A cost raster identifies the cost of traveling through each cell in any study extent. In this lab, an optimal path between two points is determined after taking subject preferences into consideration using the cost surface raster. Initially, all the input datasets, including roads, streams, land cover and DEM, were downloaded from the MN Geospatial and then imported to ArcGIS Pro. The reclassify tool is then used to standardize all the criteria layers based on a scale of 1 to 10. Subsequently, input datasets were overlayed after assigning them different weights using two different weighting approaches: weighted overlay and weighted sum. Finally, a spatial analyst tool, Optimal Region Connection, was used to get at least three optimal paths between the two predefined points.

Problem Statement

Map algebra and cost modeling are used to create cost surfaces. In this lab, an imaginary person named Dory wants to travel from her farm location (44.127985, -92.148796) to the North Picnic area (44.049801, -92.050226) but there are some specific preferences while selecting a route. Dory doesn't prefer to walk through farm fields, cross water bodies if there is no bridge, or take a steep path. The cost surface that represents these preferences using map algebra is created. Uncertainty analysis is done by incrementally altering each model weight and re-running the model to learn how different choices might impact the map outcomes.

Table 1. Required Data for the cost surface.

#	Requirement	Defined As	(Spatial) Data	Dataset	Preparation

1	MN Counties	Shapefile of all counties in the state of Minnesota	Vector (Polygons)	Mn GeoSpatial Commons	No
2	Road network	Raw vector data to locate all roads in the study extent.	Raster	Mn GeoSpatial Commons	Yes (Reclassification)
3	Streams	Raw vector data to locate all streams in the study extent.	Vector (Lines)	Mn GeoSpatial Commons	Yes (Reclassification)
4	Digital Elevation Model	Raster data to determine slope in the study extent.	Raster	Mn GeoSpatial Commons	Yes (Reclassification)
5	Land cover	Raster data to determine landuse in the study extent.	Raster	Mn GeoSpatial Commons	Yes (Reclassification)
6	Starting and End Points	CSV file containing coordinates of Dory's starting & end point.	CSV	-	Yes

Input Data

The input datasets required to create the cost surfaces using map algebra and cost modeling are tabularized below. There are, in total, six datasets considering all of the subject's route preferences and starting and end points of the route.

Table 2. Input datasets.

#	Title	Purpose in Analysis	Link to Source
1	MN Counties	For study extent	https://gisdata.mn.gov/dataset/bdry-counties-in-minnesota
2	Road network	The subject (Dory) prefers to cross water bodies as long as there is a bridge. This layer will represent all the roads that cross the streams in the study extent.	https://gisdata.mn.gov/dataset/trans-roads-mndot-tis
3	Streams	The subject (Dory) prefers to cross water bodies. This layer will represent all the streams in the study extent.	https://gisdata.mn.gov/dataset/water-strahler-stream-order
4	Digital Elevation Model	One of Dory's preferences is not to take the route that has a steep slope. This dataset will provide information about the slope in the study extent.	https://gisdata.mn.gov/dataset/elev-30m-digital-elevation-model
5	Land cover	One of Dory's preferences is not to walk through the fields. This dataset will tell how the study extent is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types.	https://gisdata.mn.gov/dataset/biota-landcover-nlcd-mn-2019
6	Starting and End Points	CSV file containing coordinates of Dory's starting & end points.	-

Methods

In order to produce the cost raster, all input datasets were combined. But before that, the reclassify tool was used to standardize the criteria based on a scale of 1 to 10. A score of one was given to the most preferred choice, while ten was for the least preferred choice. The reclassified input raster layers are overlayed in this lab by multiplying each raster cell's suitability value by its layer weight and then combining the values to produce a suitability score. Since this lab is a continuation of lab 02 part 1; therefore, the methodology is pretty much the same and it is summarized in the flow diagram, shown in Figure 1.

Figure 1: Flow Diagram of the entire Methodology.

For this lab, two overlay techniques were used, and input weights were changed each time drastically. A spatial analyst tool, namely Optimal Region Connection, was used to get the desired optimal paths between the two predefined points. The inputs for the said tool are Dory's starting and destination points and weighted overlays.

Results

The aim of this lab was to determine three optimal paths by performing cost surface analysis in a defined study extent after taking subject preferences into consideration using map algebra. The methodology described in figure 1 is followed to get all the outputs. The reclassified layers of *Stream, Roads, slope and Land Cover*, and weighted overlay analysis are shown in figure 2.

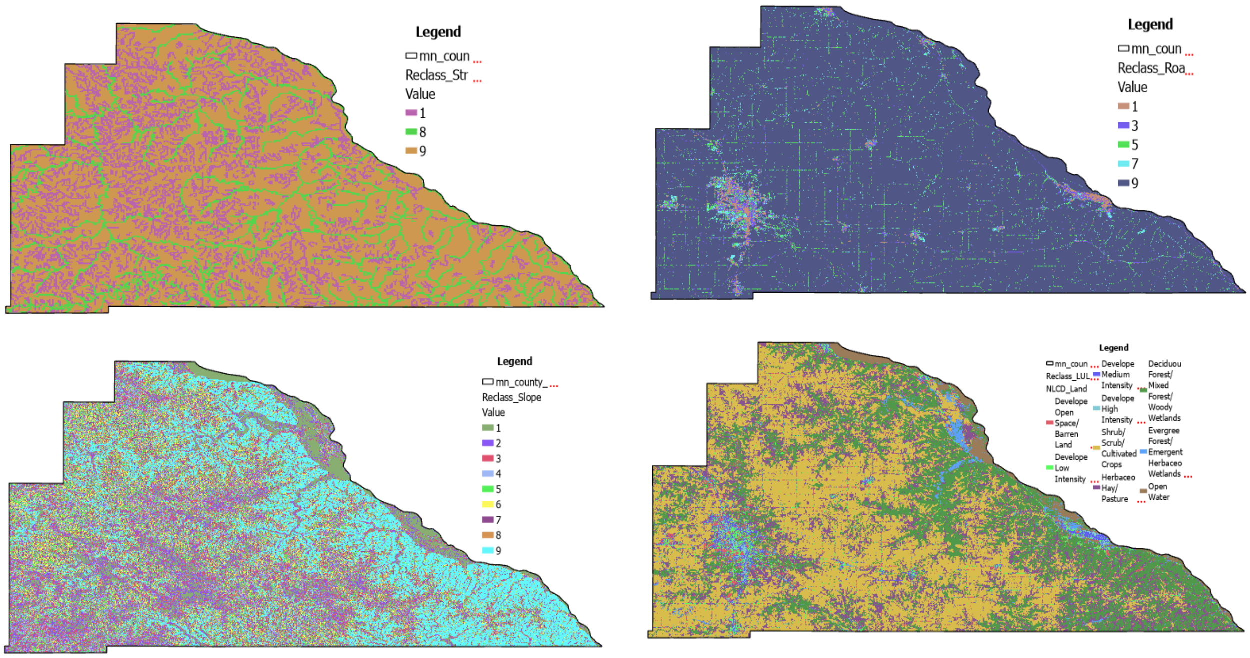

Figure 2: Reclassified Stream, Roads, Slope and Land Cover Layers

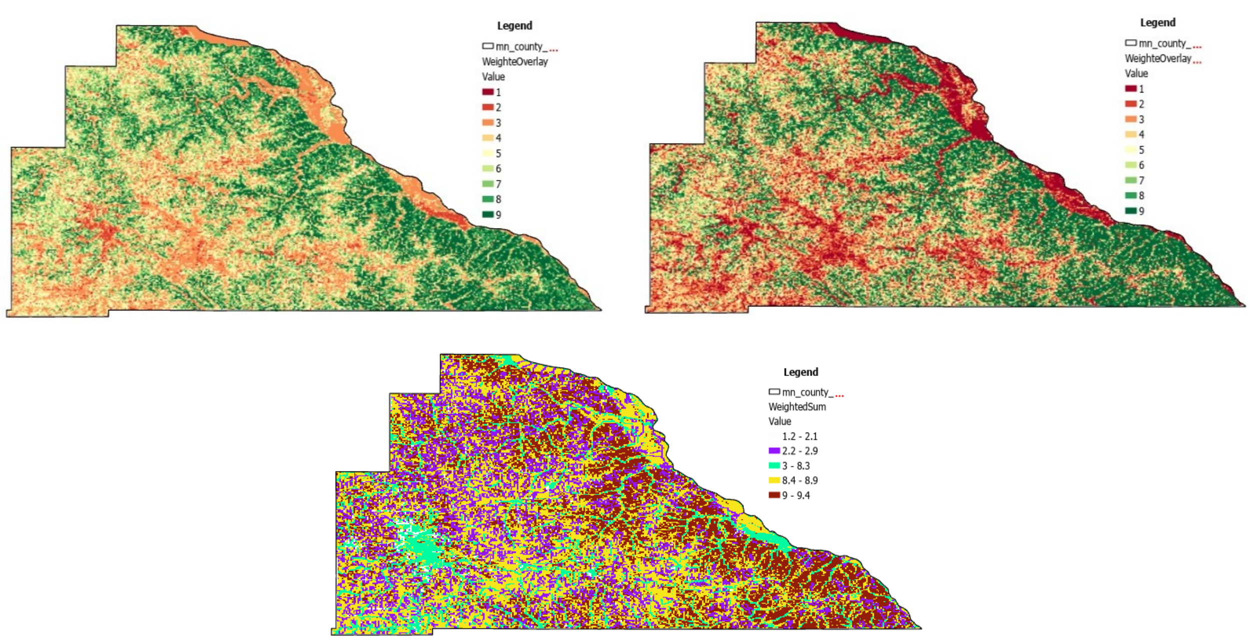

Figure 3: Cost Surface Rasters using weighted overlay (top 2) and sum techniques.

Subsequently, overlayed input datasets, after assigning them different weights using two different weighting approaches such as weighted overlay and weighted sum, are shown in figure 3. Finally, the desired optimal paths using Optimal Region Connection are shown in figure 3.

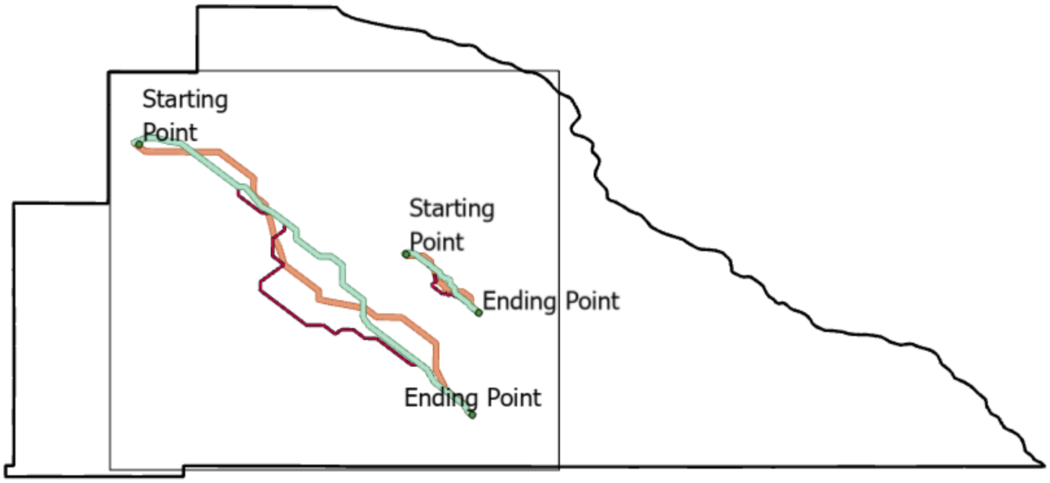

Figure 3: Optimal Paths between Dory's starting and destination points.

Results Verification

The results were verified after altering each criteria's weight and re-running the overlay tools several times. I observed very few changes in the generated path between starting to endpoints, which is an indication that the model was working perfectly fine. Moreover, it was visually verified by mapping the path in google earth and observing the features it has been crossing. In a nutshell, I would say that the optimal path justifies all of Dory's preferences.

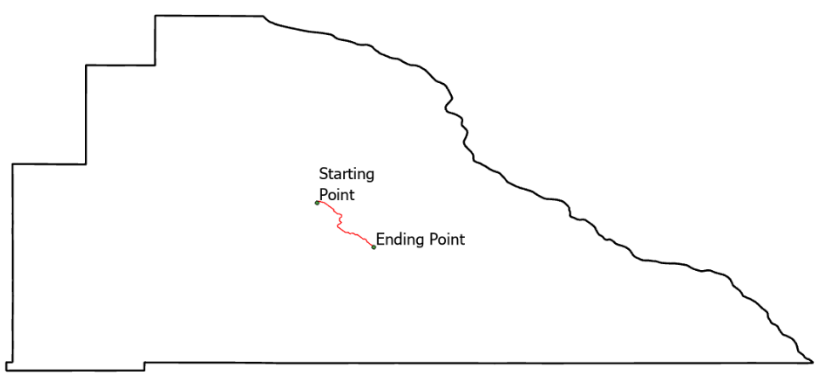

Figure 10: Optimal path determined when input weights were altered and set not equal.

Discussion and Conclusion

For this part of the lab, I learned about different methods, such as Optimal Region Connection and Optimal Path as Line, through which an optimized path between two predefined points can be generated. I tried several weighting combinations to get different paths and compared the results each time. Moreover, I enhanced my spatial analysis skills by applying several geoprocessing tools on raster and vector datasets. This part of lab 03 was something I enjoyed working on.

References

1. Creating a cost surface raster. ArcGIS for Desktop. ESRI. Website. October 24, 2022. https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/creating-a-cost-surface-raster.htm
2. County Boundaries, Minnesota. MN Geospatial Commons. Website. October 27, 2022. https://gisdata.mn.gov/dataset/bdry-counties-in-minnesota
3. Roads, Minnesota, 2012. MN Geospatial Commons. Website. October 27, 2022. https://gisdata.mn.gov/dataset/trans-roads-mndot-tis
4. Stream Routes with Strahler Stream Order. MN Geospatial Commons. Website. October 27, 2022. https://gisdata.mn.gov/dataset/water-strahler-stream-order
5. Minnesota Digital Elevation Model - 30 Meter Resolution. MN Geospatial Commons. Website. October 28, 2022. https://gisdata.mn.gov/dataset/elev-30m-digital-elevation-model
6. NLCD 2019 Land Cover, Minnesota. MN Geospatial Commons. Website. October 28, 2022. https://gisdata.mn.gov/dataset/biota-landcover-nlcd-mn-2019

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	28
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	28
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	100