GE3238 GIS Design and Practices
Semester 2, AY2024-2025
Handout: 27 Jan 2025, Due: 23:59, 5 Feb 2025 (WED)

LAB 1: PATH ANALYSIS AND NETWORK APPLICATIONS

This lab assignment has six tasks. Tasks 1 covers path analysis. It is meant to provide an example of path identification in raster. Tasks 2 to 5 require the use of the Network Analysis tools in ArcGIS. Task 2 covers basic network dataset creation. Task 3 runs a shortest path analysis. Task 4 runs a closest facility analysis. Task 5 runs an allocation analysis. The data for this lab (Lab01Data.zip) can be downloaded from Canvas.

As this is a level 3000 course, it is expected that you possess knowledge and software skillset acquired from other prerequisite modules, especially GE2215 or its equivalent. If you face any difficulties or have any queries, please feel free to reach out to the teaching assistants (HAN Baoyan, baoyanhan@u.nus.edu) and me. The forum on Canvas is also a good channel to get your questions answered.

Task 1: Compute the Path Distance

In this task you will need:

- BukitTimahDEM.tif, an elevation raster
- BukitTimahPeak.tif, a source raster with one (source) cell
- Locations.tif, a path raster that contains three cells representing three (destination) locations

Note: All three rasters are projected onto Transverse Mercator coordinates in meters. The task also try to use minimum number of data layers. In real applications, more data layers are often required.

You will find the least cost path from each of the three cells in Locations.tif to the source cell in BukitTimahPeak.tif. The least cost path is based on path distance. Calculated from an elevation raster, the path distance measures the ground or actual distance that must be covered between cells. The source cell is at a higher elevation than the three cells in Locations.tif. Therefore, you can imagine the objective is to find the least cost (shortest distance) hiking path from each of the three cells in Locations.tif to the source cell in BukitTimahPeak.tif.

1. Insert BukitTimahDEM.tif, BukitTimahPeak.tif, and Locations.tif to the default map window (likely named Map). For convenience, in this task the map will be named Map_Task1.

2. Change the symbology of BukitTimahDEM.tif to Elevation #1 to see more clearly the terrain relief.
    - As shown in Map_Task1, a cell in BukitTimahPeak.tif, which in this task refers to the source raster in ArcGIS Pro, is located at the summit of the elevation surface.
    - Three cells in Locations.tif, which represents locations referred to as destinations in ArcGIS Pro, can be found in lower elevation areas.

3. Find the Slope (Spatial Analyst Tool) to produce a slope layer based on BukitTimahDEM.tif. Observe the parameters available for the tool, especially the two options under Method. For this task, we will take default parameters for all.

4. Find the Distance Accumulation geoprocessing tool in the ArcGIS Pro tool box. Select BukitTimahPeak.tif for the input raster (for feature sources), specify pathdist1 for the output distance accumulation raster, select BukitTimahDEM.tif for the input surface raster, BukitTimahSlope for the cost, and specify backlink1 for the output backlink raster. Click Run to proceed.

Q1. What does the cell value of pathdist1 refer to? (1 mark)

Q2. The above analysis is carried out with BukitTimahSlope.tif being used as the input cost raster. If instead of BukitTimahSlope.tif, BukitTimahDEM.tif is used as the cost layer, what would the cell value of pathdist1 refer to? (1 mark)

5. Find the tool Optimal Path As Raster in the ArcGIS Pro tool box.

6. Select Locations.tif for the input raster, select pathdist1 for the input distance accumulation raster, select backlink1 for the input back direction or flow direction raster, path1 for the output raster, and each cell for path type. Click Run to proceed.

7. Convert path1 layer from float to integer. This can be done by int function in raster calculator. After conversion, you should be able to open the attribute table of path1.

Q3. Produce an analysis result showing the shortest paths (i.e., shortest distance) from the peak to the three locations. Attach a screen capture of your result in your submission document. (1 mark).

Q4. Are you able to find individual distances between the peak and the three locations from the attribute table? If your answer is yes, please provide your reason. If your answer is no, propose how you may be able to find the path cost (1 mark and 2 marks).

8. Make sure you save your analysis result as they will be part of the submission.

Task 2: Build a Geodatabase Network Dataset

For the purpose of this task, you will need:

- moscowst.shp, a line shapefile containing a street network in Moscow, Idaho
- select_turns.dbf, a dBASE file that lists selected turns in moscowst.shp

The shepfile moscowst.shp was compiled from the 2000 TIGER/Line files and projected onto a transverse Mercator coordinate system in meters. For this task, you will first examine the input data sets and then build a file geodatabase and a feature dataset. Afterward, you will import moscowst.shp and select_turns.dbf as feature classes into the feature dataset. The network dataset built in this task will be used to run network analyses in the next three tasks.

Creating a network dataset is traditionally possible with the earlier version of ArcGIS, i.e., ArcGIS Desktop. However, starting with ArcGIS Pro, this is not doable. If your input data is in shapefile format, you will need to import it into a geodastabase as a feature class first.

1. Import moscowst.shp into your default geodatabase (*.gdb) in the project. For this task, I will use network.gdb for the geodatabase name. Note that moscowst, now a (polyline) feature class in a geodatabase, has the following attributes important for this task:
   - MINUTES shows the travel time in minutes,
   - ONEWAY identifies one-way streets as T,
   - NAME shows the street name, and
   - METERS shows the physical length in meters for each street segment.

Q5. How many one-way street segments (records) are in the moscowst feature class in network.gdb? (1 mark)

2. Preview the table of select_turns.dbf. select_turns.dbf is a turn table originally created in ArcInfo Workstation. The table has the following attributes important for this task:
   - ANGLE lists the turn angle,
   - ARC1_ID shows the first arc for the turn,
   - ARC2_ID shows the second arc for the turn, and
   - MINUTES lists the turn impedance in minutes.

3. Create a feature dataset. Right-click Network.gdb, point to New, and select Feature Dataset. In the next dialog, enter MoscowNet for the name. Then click Coordinate Systems to import the coordinate system of moscowst feature class to be MoscowNet's coordinate system. Click Run.

4. This step makes the MoscowSt feature class as part of a dataset for supporting network-based analysis. This can be done easily by dragging the feature class and dropping it to MoscowNet feature dataset. As indicated in the lecture, this means that data layers in this dataset must share something in common, e.g., map projection.

5. To add select_turns.dbf to MoscowNet, you need to use geoprocessing tool Turn Table to Turn Feature Class. Find the tool in the toolbox and specify select_turns.dbf for the input turn table, MoscowSt feature class in the MoscowNet feature dataset that you created in step 3 for the reference line features, enter Select_Turns for the output turn feature class name. Use default for the remaining two parameters and click Run.
   - Expand MoscowNet in the Catalog pane, which is usually located on the right side of the ArcGIS Pro window. MoscowSt and Select_Turns should be in the dataset.

6. With the input data ready, you can now build a network dataset. In the Catalog pane, right-click MoscowNet, point to New, and select Network Dataset. Specify the network dataset name to be MoscowNet_ND, select MoscowSt and Selected_turns to participate in the network dataset, and choose No elevation for the Elevation Model. Click Run.

   As a reminder, this step is essentially creating a connectivity-based dataset using a data model from ArcGIS called network dataset. The data to populate the dataset are from the two data layers in Step 6.

Q6. Other than the input data set, what are the new feature class created by the build network tool? (1 mark)

7. The network dataset MoscowNet_ND should now be created. However, it will still need to go through a "build" process, which is similar to the last step in topology checking, during which a few data quality checkups are carried out. Right click MoscowStNet_ND. In the dropdown menu, select Build and click Run.
   - You may want to add MoscowNet_ND_Junctions to the map to have a good sense of the auto-generated junctions. They mostly play the roles of intersections unless marking the ends of edges.

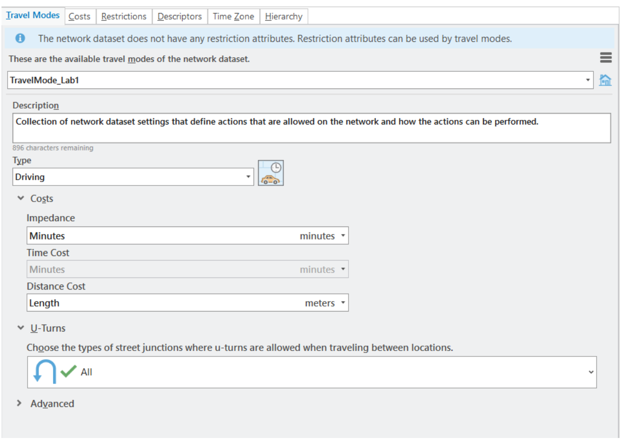
Other than building the connectivity, which is considered the most fundamental piece of information needed for the analyses using a transportation network, you could elect to add/customize costs to move on your network. The following steps demonstrate adding time as a measure of cost.

8. Right click on MoscowNet_ND. In the Network Dataset Properties box, choose Travel Attributes. We will look specifically at specifying time as a cost to travel on street segments.
   - If you have loaded MoscowNet_ND into a map window, you may need to remove it before updating the network dataset.

9. Select Costs tab, and add a new cost item by clicking on the hamburger-like icon near the upper right corner of the dialog box. Click New. In the properties group below, name the cost as Minutes.

10. The most important part of adding a property to the network (in this case either a new cost or a new restriction) is to assign appropriate evaluators. For Minutes cost, you should see one row for moscowst (Along) and moscowst (Against). Please be reminded that this is one place where the notion of direction is being recognized.
    - For moscowst (Along), change the Type to Field Script to indicate that you want to use one or more fields in the attribute table for the cost by time. Click on the cell under the Value field, and then the Field Script Setting icon that should appear on your screen. Specify !Minute! in the Result box and click OK.
    - For moscowst (Against), choose Same as Along for the Type. Its value should be filled automatically.
    - Keep the dialog box open for the next step.

11. Select Travel Modes tab and add a new travel mode. This step is straightforward, with the available information, including time cost and distance cost, being populated automatically. Your travel mode should be quite similar to the screen capture shown below.



12. At this point it would be a good idea to build MoscowNet_ND again.

Q7. With moscowst feature class participating in MoscowNet_ND, it seems that further refinement of MoscowNet_ND is possible to model more accurately the movement behaviors on the road in Moscow, Idaho, USA. Please suggest how you may use the information in moscowst feature class to improve the current MoscowNet_ND, and briefly describe the steps you would take. Please keep your answer to at most ½ page. The shorter the better. (3 marks)

Task 3: Shortest path

1. Add a new map to your project file, give it an easily recognizable name, e.g., Map_Task 3. Add the MoscowNet_ND to Task 3 map.

2. Under the Analysis ribbon, select Network Analysis and then Route. The step will create a set of layers with predefined symbology, designed for shortest path analysis.
   - As indicated in the lecture, these sublayers represent components of a pre-defined (network) data model, which are implemented in geodatabase. Additionally, at this point, these sublayers do not contain any data, meaning that the part of the database for supporting

3. Enter four stops to the route analysis tool to test its functionality. This can be done by digitizing four random stops using the Create Features tool within the Input Data group (usually the second group from the left) of the Route Layer ribbon. Make sure that you select Stops in the Create Features pane, usually shows up on the right of ArcGIS Pro window.

4. Run the Route analysis.

Q8. Provide a screen capture of your route analysis result. (1 mark)

Q9. Does the route analysis have built-in supports for traveling salesperson problem? If so, what is the tool that supports the said application and Why? (2 marks)

Task 4: Find Closest Facility

In addition to the MoscowNet that you have just created in the previous task, Task 4 requires:

- firestat.shp, a point Shapefile with two fire stations in Moscow, Idaho

2. Import firestat.shp to network.gdb as a feature class under MoscowNet feature dataset.

3. Insert a new map into your project and rename it Map_Task4. Add both the MoscowNet_ND and firestat to Task 4.

4. Similar to Task 3, go to Network Analysis tool and make sure that MoscowNet_ND is

the network dataset you would like to tap into for this analysis. Select New Closest Facility from the Network Analyst dropdown menu. The Closest Facility layer is added to the table of contents with sublayers of Facilities, Incidents, Routes, and Barriers (Point, Line, and Polygon).

5. Click the Closest Facilities Layer tab on the menu to navigate to the tools/options associated with finding closest facilities. In the Input Data group, click Import Facilities and select firestat feature class.

6. Click the Closest Facility Layer from the menu. In the Travel Settings group, opt for 1 for the Facilities and Away from facilities for the Directions.

Now you could enter a specific location of your choosing as the location of an incident. In ArcGIS, this is nothing more than digitizing a new point, except that the point must go to the specific layer named Incidents.

7. In the Input Data group of the Closest Facility Layer, click the Create Features button, and make sure that Incidents layer is selected in the Create Feature pane that should have popped up on the right side of your ArcGIS window.

8. Click a location on the map to digitize an incident point, and click the Run button to identify the closest fire station to the incident location. The map should show the route connecting the closest facility to the incident. Your result should show a route from one of the fire stations to the incident location. If not, check carefully if you have missed any steps above.

Q10. Suppose an incident occurs at the intersection of 'D Street' and 'Garfield St'. How long will the ambulance from the closest fire station take to reach the incident? (1 mark)

Task 5: Find Service Area

1. Follow the steps for Route or Closest Facilities analysis, create a new map, add MoscowNet_ND to the map, and create Service Area analysis in this map.

2. In the Service Area Layer ribbon, find Travel Setting group.
   - The travel mode created in Task 2 is automatically selected as it is the only travel mode available for this lab. Note "Min" is used with this travel mode.
   - For the Travel Settings group, enter "2, 5" for the Cutoffs of 2 and 5 minutes, check direction to be Away from facilities.
   - For the Output Geometry group, select Polygons as the output geoemtry, opt for Standard precision generalized polygon type, select Dissolve (polygons for multiple facilities), and choose rings for the overlay type. Click OK to dismiss the Layer Properties dialog.

3. Add fire stations as the facilities. Click to calculate the fire station service areas. The

service area polygons now appear in the map as well as in the Network Analyst window under Polygons (4). Expand Polygons (4). Each fire station is associated with two service areas, one for 2 minutes and the other for 5 minutes. To see the boundary of a service area (e.g., 2 to 5 minutes from Location 1), you can click a service area.

Q11. Attach a screen capture of your 4 service area polygons. Make sure the map distinguishes the 2- and 5-minute service areas. In addition to the service area map, what is the size of the 2-minute service area of Location 1 (fire station 1)? **(1 mark each)**

--- End of instruction ---

Reminder

- Please submit your typed answers in a Word document (**No PDF** please) to Canvas, **Lab01 submission** assignment folder. The file name must follow the **last_name-first_name-metric_number.docx** convention.
- The submission should include a compressed file (**last_name-first_name-metric_number.zip**) that contains all the files in your working folder.
- Late penalty applies.

Just zip the whole project folder