Assignment 4: Surface Analysis

Due: April 5

Introduction

Objectives
- to explore various ways to interpolate a surface from point data
- to practice your map design skills

Part A: Theory

Textbook Readings
- Chapters 7 and 8
- You may also find a review of Chapter 6 helpful.

Questions

(each question is worth 2 marks)

1. What is meant by the *ecological fallacy* issue in GIS? Give an example.

2. Describe and provide an example of the *Modifiable Areal Unit Problem (MAUP)*.

3. What are *process models*? Describe and give an example of each of the three basic types of process models.

4. Describe the *multi-criteria evaluation (MCE)* approach to modelling the decision-making process. When have you used the MCE approach in this course?

5. What is *public participation GIS (PPGIS)*? When might PPGIS be used?

6. Discuss four problems with using GIS to model spatial problems.

7. Why is map design an important consideration when creating maps using a GIS?

8. Briefly describe the main elements of a map?

9. Briefly describe the six class interval systems available in ArcMap.

Part B: Surface Modelling

A common task for many geography researchers is to study the spatial distribution of some real feature (e.g., an endangered species). Since it is impossible for the researcher to measure the feature *everywhere*, sampling locations are chosen to allow the researcher to capture as much of the variation in the feature as possible. The researcher will then want to map the attributes of their field observations and extrapolate them to a continuous surface to try and characterize their spatial distribution. When they collect their field data, they are taking samples of reality. When they extrapolate their sample data, they are trying to re-create, or predict, reality.

B.1: Guided Tutorial

In Assignment 3 you explored some of the methods to analyze raster data by following parts of the on-line tutorial: *Learning ArcGIS Spatial Analyst*. In this assignment, you will complete the remaining modules of this tutorial to learn about the different methods of surface interpolation.

1. Go to: http://training.esri.com and select **Start or Continue Your Courses** from the left-hand menu.

2. Select **My Virtual Campus Courses** and then log in.

3. You will see the course *Learning ArcGIS Spatial Analyst* appear in your course list. Click on it to continue with the tutorial.

4. Complete **Modules 4 and 5**.

Notes

- You should allocate about 4-5 hours to complete this part of the tutorial.

- Before you begin, you need to create 2 new scratch geodatabases to get around an ArcGIS version 9 to version 10 incompatibility:

  o Start ArcMap and do not open any existing map documents.

  o Open the **Catalog** by clicking on the tab along the right of the ArcMap window.

  o Navigate to the folder where you saved the Learning ArcGIS Spatial Analyst data from Assignment 3. If you no longer have these data, start the tutorial to find the instructions on how to download them.

  o Right-click on the **Interpolate** folder (in the LearnSA9 folder) and select **New → Personal Geodatabase**.

  o Name your new geodatabase **Scratch**.

  o Right-click on the **DisDen** folder (in the LearnSA9 folder) and select **New → Personal Geodatabase**.

  o Name your new geodatabase **Scratch**.

  o Now you can begin to do the exercises.

- For each of the exercises in Modules 4 and 5 you need to change the scratch data destination from the pre-defined location to your new geodatabase.

  o In Step 1 of each exercise, open the map document as instructed.

  o Before going on to Step 2, select **Geoprocessing → Environments… → Workspace** and change the **Scratch Workspace** to be the **LearnSA9\...\Scratch.mdb** file you created previously.

  o Now, when you run a tool in the exercise the output raster location will default to your scratch geodatabase and the tool should run without error. Also note that whenever the instructions reference a scratch raster, just substitute your scratch.mdb geodatabase.

- In Step 8 of the Module 4 exercise: **Explore different interpolation methods**, you are instructed to create Groups from feature layers in the table of contents. In order to see the groups you may need to change the table of contents view to **List by Drawing Order**.
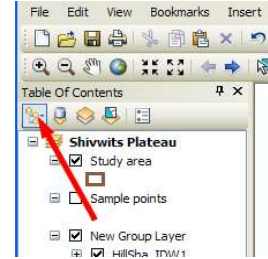
- In the Module 5 exercise: **Air ambulance study**, when you need to specify an Input Raster for one of the tools, you may see 2 instances of the file you are looking for in the pull-down menu. The correct one to select is the one with the blue recycling symbol ♻ beside it.

- In Step 10 of the Module 5 exercise: **Air ambulance study**, substitute the **Raster Calculator** for the Single Output Map Algebra tool. The syntax of the CON (conditional) function has changed slightly between ArcGIS 9 and 10. It is essentially the same as is written in the tutorial except that the square brackets, [and], are replaced with "% and %". The CON is a complicated expression, but try to follow the tutorial to understand what it is saying. For simplicity, you can copy the CON function below and paste it into the Raster Calculator:

```
Con( ("%Direction to hospital%" > 0)  & ("%Direction to hospital%"  <= 180),
"%Direction to hospital%" + 180, Con("%Direction to hospital%" > 180,
"%Direction to hospital%" - 180, 0) )
```

- In Step 7 of the Module 5 exercise: **Find the least-cost path** some statistics need to be calculated for the land use feature before the reclassification will work. Consequently, at the start of Step 7, insert Step 7a as follows:

  o From the **Data Management Tools / Raster / Raster Properties** toolset, drag the **Calculate Statistics** tool into the model.

  o In the model, double-click the Calculate Statistics tool and fill out its parameters as follows:

    ▪ Input raster: click on the open folder icon and select **LearnSA9\DisDen\Otay.gdb\newlanduse**

    ▪ Click OK

  o Rename the input element from newlanduse (2) to Land Use.

  o In the model, right-click the Calculate Statistics tool element and choose Run.

  o You do not need to add the results to the display because they are used as direct input to the reclassification procedure.

  Now you can add the Reclassify tool into the model and fill out its parameters as described in Step 7, except select **newlanduse** instead of Land Use as the Input Raster.

Questions

(each question is worth 2 marks)

10. What are 3 ways to create a smoother surface when interpolating with IDW?

11. A spline interpolation is best used when the sample point locations are _____ and the surface is mostly _____ and does not include any _____.

12. What is the difference between Ordinary Kriging and Universal Kriging?

13. In Step 7 (Exploring the Allocation to hospital layer) of the Air ambulance study exercise in Module 5, the allocation layer shows the division of the study area into regions where the cells in each region are assigned to the nearest hospital. If you converted these regions into vectors, what would be the name for the type of polygons created?

B.2: On Your Own – Surface Interpolation

Assume you are interested in mapping some climate data for Saskatchewan. In particular, you would like to produce a map that shows the total annual precipitation based on selected Saskatchewan climate stations.

Selected Saskatchewan Climate Stations

Estevan	Kindersley	La Ronge
Lloydminster	Moose Jaw	North Battleford
Prince Albert	Regina	Rosetown
Saskatoon	Swift Current	Yorkton

Obtain Climate Data

1. Prepare an Excel spreadsheet to record your climate information. Enter the following column headings across the first row in the worksheet:
   Station   Latitude   Longitude   Precipitation

2. Open the Environment Canada Climate Normals web page at
   http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html

3. For each climate station listed above, type its name into the **Location** box and click *Search*. *Note:* If your search produces several choices for the named location, select the one that ends in the single letter, "A". This designates the airport location - a location that is likely reliable.

4. Enter the *station name* and its *latitude* and *longitude* into your Excel spreadsheet. *Notes*:
   a. The latitude and longitude are shown on the website in *degrees* and *minutes*. You need to enter them in the spreadsheet in *decimal degrees*, however. Follow this procedure to do the conversion:

      Example: convert 49° 13' N into decimal degrees

49 degrees	→ copy	49 degrees
13 minutes	→ ÷ 60	13 / 60 = 0.22 degrees
	answer	49 + 0.22 = 49.22

Thererefore: 49° 13' N = +49.22 decimal degrees

b. By convention, latitudes north of the equator are written as positive (+) numbers and latitudes south of the equator are written as negative (-) numbers. Similarly, longitudes east of Greenwich are written as positive (+) numbers, and longitudes west or Greenwich are written as negative (-) numbers.

c. Thus, the location:
   49° 13' N, 102° 58' W
is written in decimal degrees as:
   +49.22, -102.97

5. In your Precipitation column, record the value in the website table under **Precipitation (mm)** in the second last column (**Year**). For Estevan, this value is 433.3.

6. When you have collected the Precipitation data for all the stations, *Save* your Excel spreadsheet.

Import your Data Table into ArcGIS

7. Now you are ready to import this table into *ArcMap*. Select **File → Add Data → Add XY Data…**

8. Open the *Excel* file that you just created and select the first Table (typically called **'Sheet1$'**) that is listed in the *Add* window.

9. ArcGIS needs to know which columns in your file contain the information you wish to map.
   a. For the **X Field** select your **Longitude** column.
   b. For the **Y Field** select your **Latitude** column.

10. Tell ArcGIS how your data have been georeferenced.
   a. Click **Select…** to Select a predefined coordinate system.
   b. Select **Geographic Coordinate Systems** to let ArcGIS know that your data have not been projected.
   c. Select **North America → North American Datum 1983.prj**. Click **Add** and **OK**.
   d. Click **OK**.
   e. You may receive a warning that your *Table Does Not Have Object-ID Field*. This message is reminding you that you will need to save your data in ArcMap

before you will be able to do any analyses with them. Click **OK** and your points should be displayed in the view.

    f. To save these points in ArcMap, right-click on your point file at the top of the ArcMap Table of Contents and select Data → Export Data… Select:

        i. Export: **All features**
        ii. Use the same coordinate system as: **this layer's source data**
        iii. Output shapefile or feature class: specify a filename for a new shapefile to be created or navigate to an existing geodatabase.
        iv. Click **OK**.

    g. Add the exported data to your map as a layer.

    h. Right-click on your previous XY Event table and select **Remove**.

11. You can find additional data for your map on TerraServer.

Surface Fitting

12. Interpolate your data using Inverse Distance Weighting, Spline, Natural Neighbours, and Kriging. For each map:

    a. You should experiment with the weighting and/or search radius parameters available in each method and select the combination that you think produces the best result.

    b. Write a short paragraph describing the interpolation method. Your method descriptions should be a mixture of the ArcGIS description, the explanation from your text, and (possibly) other sources (e.g. the web). Be sure to also mention the weighting and search radii you used.

    c. Write a short paragraph analyzing your results. Compare the properties of the method with the other statistical surface interpolations you tried.

    d. Create an effective map layout for your statistical surface interpolation. Expand your surface to cover the entire province of Saskatchewan and clip your map to the Saskatchewan borders. Note that you will not be able to expand your Natural Neighbours surface to the Saskatchewan borders; just map this surface as it is produced.

Mapping Assignment 1   **(12 marks)**
Submit each of your 4 statistical surface interpolations and their accompanying analyses and methods descriptions.

B.3: On Your Own – Density Surfaces

Records of "break and enter" crimes in the City of Regina for the first 4 months of 2005 can be found in the file **2005 B&E.shp** that is in the City of Regina folder on TerraServer. These data were obtained from the Regina Police Service. Note that the locations of the break and enter crimes listed in the file have been modified from their true locations for reasons of confidentiality.

Create kernel density maps identifying the locations of break and enter "hotspots".

1. You should experiment with different search radii until you find one (or more) that in your mind effectively show the patterns of crime.

2. Create one map for night-time crimes and one map for day-time crimes.

   - In many cases, the break-in occurred when the occupant was not present, so the actual time of occurrence is unknown. The attribute **TT_2400** is the time, on a 24h clock, that the break-in was discovered. This "discovery time" is the best estimate we have for the actual time of the event.

3. Write a short paragraph for each map describing the patterns that you see. Be sure to indicate the search radius you used when you ran the kernel density.

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Mapping Assignment 2   (6 marks)
Submit your day-time and night-time break and enter maps along with their description paragraphs.

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