Geog 176A: Introduction to GIS, Fall 2016
Prof. Dr. Werner Kuhn and Teaching Assistants

Lab 3: Objects

Objectives

Through this lab, you will gain a deeper understanding of the concept of a geographic object, by experimenting with and producing object data. You will learn how to generate, use, and analyze object data in the key application area of facility management. In the context of the solar panels study, and with rooftops as objects, you will learn how to query their properties in a GIS, how to generate additional **object** data from a **field**, and how to analyze **objects** (building rooftops) combined with a **field** (of insolation).

Tasks

Provide a technical report (as a single pdf uploaded in GauchoSpace) with precise answers to the following questions. Purple asterisks (*) indicate that the question requires a screenshot (points get deducted for lacking screen shots!). Use [ArcMap]() for all the GIS tasks (the necessary ArcMap tools are indicated in each task). Note that many of the tasks in this lab build on what you learned about **field** data in lab 2 (29 points possible).

1. **Preparations** (no responses needed)
    a. Download the Lab 3 Resources ZIP and extract it to your local machine.
    b. Create a folder within this extracted folder where you will save all of your ArcMap work. Assume all operations use layers' default coordinate system.
    c. Load Cal Poly rooftops (Rooftops.shp) into ArcMap.
2. **Query object** data in GIS
    a. Remember that rooftop surface areas are important for solar panel placement; typically, rooftops with smaller areas aren't worth installation. Open the attribute table for Rooftops.shp and select two rooftops from Cal Poly rooftops. *Calculate the Geometry* (area) for these rooftops in the column *Shape_Area*. Report the names of the two buildings and their surface area measurements, including the units (2 points).
    b. * Recall how you used spatial relations to describe your location relative to Isla Vista in Lab 1. For each rooftop you selected in 2a, report its location using a spatial relation that holds between the rooftop and its surroundings. Add a basemap for additional context and use the information available in the layer's attribute table and the map. Capture a screenshot of the rooftop with the basemap (2 points).
3. **Calculate** and query spatial **properties** and **relations** of **objects**
    Campus administration is interested in finding optimal locations for installing solar panels. Using your previous knowledge of fields and new knowledge of **objects**, determine the best rooftops for installation. Before investigating the variables needed to find an optimal solution, in 3a-3c, refresh your memory on **location** by figuring out which campus regions might want to consider solar panel installation.

a. * Using the *Feature to Point* tool, generate a vector layer consisting of centroid points of all rooftop polygons. Take a screenshot of any rooftop and report the coordinates of its centroid using the *Identify* tool (2 points).

b. * Import the Cal Poly rooftop centroid distances (Centroid_Distances.csv) data as an attribute table (generated for you from centroids). It is a lookup table for distances between points. In ArcMap, query the attribute table to figure out how far away the farthest centroid is from the rooftop you selected in 3a. Look at the centroid layer to find your building ID. Capture a screenshot of the highlighted selected rooftop on the map that is furthest from your queried rooftop (2 points).

c. Without performing a measurement, explain in your own words a method (other than computing centroids) for measuring the distance between two polygons. In what situations would you recommend your method, because centroids would be a poor representation for computing distances? (3 points)

d. * After exploring location, start investigating decisive variables for placing panels. First, assess the complexity of the shape of each rooftop polygon, as a rooftop that has too complex a shape may not have enough regularly shaped area for installation. Find the column *Shape_Leng* and *Calculate the Geometry* of the shape length (perimeter in meters) of each rooftop as you did for the area Shape_Area using Calculate Geometry. Then, use the *Field Calculator* to divide the shape length (numerator) by the square root of the shape area (denominator). Add the values as a new column called Complexity to your centroid layer's attribute table. Report and interpret the complexity of your chosen rooftop's polygon along with its object ID and a screenshot (2 points).

e. * Using the distance and complexity information that you've just generated, find the optimal rooftop <u>shape</u>. First, select all rooftop centroids within 250 meters of your chosen centroid (from 3a & 3b) using *Selection by Location*. From this selection, query for rooftops with areas greater than 1400m^2 using *Selection by Attributes*. This is a selection within the results of a selection. Of these rooftops, figure out which one has the simplest polygon geometry (excluding your chosen rooftop) and capture with a screenshot. Explain how polygon simplicity (i.e., the inverse of complexity from 3d) might help identify rooftops that enable an optimal arrangement of solar panels (5 points).

4. **Generate** additional **object** data from **field** data

a. * Now that we have found simpler shapes, we need to find rooftops that have consistent heights. Rooftops with varying surface heights also aren't optimal for installation. Remember from lab 2 that elevation is often understood as a **field** and that fields are most commonly represented as raster data, such as .tif files. First, load the Digital Elevation Model of the Cal Poly campus (Cal PolyDEM.tif) and change the symbology classified using ten equal intervals. Additionally, colorize the intervals and take a screenshot. (1 point).

b. * To observe rooftop elevation variation, apply a zonal operation by applying the *Zonal Statistics as a Table* tool to the original DEM as a **field** and the Cal Poly rooftops as zones. Join the zonal statistics table to the original Rooftops table using the object IDs as a key value. Inspect the output layer's attribute table and sort the rows by standard deviation. Select a few rows and zoom to the respective DEM image of its rooftops. Take a screenshot (3 points).

   c. * What does the standard deviation value indicate with respect to selecting suitable roofs to install solar panels on? (Hint: look at the newly appended *STD* (standard deviation of elevation) column within your Rooftops attribute table). Capture an example of a rooftop that exhibits a relatively high standard deviation for elevation with a screenshot and speculate why it might be difficult to install panels on this rooftop (2 points).
   d. In addition to shape (question 3) and surface elevation deviation (previous question 4 steps), it's important to know the slope (steepness) and aspect (angle of exposure) of the roofs. For example, if a roof is too steep or north facing, it may not catch as much sunlight during large portions of the day when compared to other configurations. Compute slope and aspect and generate associated layers from the original Cal Poly DEM using *Slope* and *Aspect* tools from the *Spatial Analyst* toolbox Then use *Zonal Statistics* (as you did in 4b) to calculate the mean slope and mean aspect for each rooftop. Finally, join the mean slope and mean aspect tables to your Rooftops table. After you join, open the Rooftop attribute table and ensure that new columns were added. These generated attributes will be used to produce **objects** and finalize our selection of candidate rooftops in question 5.

5. **Analyze object** data
   a. * Determine which buildings on campus are suitable candidates for solar installation based on all of the variables we have investigated. Produce a vector layer of only those roofs with shape complexity less than or equal to 5.5, an elevation standard deviation mean value below 2, a slope between 20 degrees, and 30 degrees and an aspect range between 112.5 degrees and 247.5 degrees. Roofs with a slight angle of exposure, facing south, southeast, or southwest, tend to get most sunshine. Take a screenshot of the selected buildings that meet these criteria. Also, capture the expression that you constructed to generate your selection with a screenshot. Report on whether the building you identified previously (in 3a, 3b) meets the criteria you evaluated. Is it in the evaluated selection? Is this building a good candidate for solar panels? Why or why not? (2 points)
   b. * Now compare the results you generated with an insolationlayer of campus. Load the layer (Insolation2014.tif) into your workspace and colorize it by changing its symbology. When selecting a color ramp, choose shades of red for high values and shades of blue for low ones. Mask the insolation field with the results of step 5a using the *Extract Mask* tool. Turn the basemap back on to visualize the building in its context. Take a screenshot of a suitable roof. Describe what the insolation value represents and why the rooftop you selected is a good candidate for solar panels (3 points).