# Lesson 8 – Generalization

## INTRO AND TASK INFORMATION

Generalization simplifies the map content to maintain the readability and comprehensibility of a map. All maps are in a considerable reduction ratio to reality. Therefore, there is a need for geometric simplification, summarisation, and schematization of the map graphics. Generalization is not photographic reduction but the considered qualitative and quantitative selection and adaption of geometric features.

* This exercise aims to apply a structured cartographic generalization of a subsequent map with GIS tools. For a topographic map of an area in the English Garden at a scale of 1: 5,000, a follow-up map at a scale of 1: 25,000 is to be produced. All elementary generalization operations learned in the lecture will be applied. We continue to use OpenStreetMap (OSM) data.

The project template is on Moodle under the *E8\_data file.* Please open the project file *Template.aprx* in ArcGIS Pro. Three project panes will open:

1. The *OSM Data View* Map,
2. A Layout view with the *1: 5,000* map scale,
3. A Layout view with the to-be generalized and symbolized *1: 25,000* map scale.

* In this exercise we apply GIS tools over the study area globally. However, the parameters in these tools are tailored to the small extent area that will be part of the layout. Furthermore, an acceptable generalization would require object-specific manual cartographic adaptions after using the global GIS tools. In this exercise, we skip manual cartographic adaptions.

## SIMPLIFYING WATER POLYGONS

The larger water bodies are modeled as polygons in OSM. In our 1:25,000 map case, there are the Kleinhesseloher See and the Isar. In automatic generalization with algorithms, several algorithms are often necessary for one object class. Here, the graphical simplification will be done in two steps.

### Reducing the Number of Nodes

* The lake is to be graphically simplified for the 1:25,000 scale by reducing the number of nodes.

1. In the OSM Data View, select the Kleinhesseloher See and the Isar in the area of the 1:25,000 map. To do this, activate the interactive selection with *Map > Select*. Now select the lake and the parts of the Isar by CLICKING with the SHIFT key pressed. ArcGIS Geoprocessing tasks are generally applied only to selected features.
2. Open the Geoprocessing pane under Analysis > Tools  and look for the function Simplify Polygon. Open it. This tool simplifies polygon outlines by removing relatively insignificant support points but retains the essential shape.
3. As *Input Features*, select the water polygons *osm\_water* and only *Use the selected records*. Choose a file path and name for the *Output Feature Class*.
4. Choose the Douglas-Peucker algorithm (see lecture), which identifies and removes relatively surplus points to simplify the data for display at smaller scales. Change the units to m or m² (Meters; Square Meters). You can set 20 m as the *Simplification Tolerance*. This is the tolerance of the maximum permissible vertical distance between each support point and the newly created line. Water areas and islands that are too small should be omitted. Therefore, select 2000 m² for the *Minimum Area*. We do not need a list of removed points. Therefore, the option *Keep collapsed points* can be deactivated. (Topological errors do not need to be checked).
5. Execute the geometric simplification with *Run*. Inspect the intermediate result.

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### Smoothing the Polygon

* The Douglas-Peucker algorithm processed lake polygon looks very edgy at first glance. We now try to correct this with the *Smooth Polygon* tool by reducing support points and applying the Bezier interpolation as a smoothing algorithm.

1. Open the *Smooth Polygon* tool
2. This time, select the simplified polygon lake only.
3. Apply a Bezier interpolation. In doing so, approximated Bezier curves are superimposed on the input polygon. (Topological errors do not need to be checked).
4. Execute with *Run*.

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* The Kleinhesseloher See is now created twice. Delete the Douglas-Peucker lake polygon from 8.2.1 by selecting it and then deleting it with *Edit > Delete* .

## AMALGAMATING WOODLANDS

* The forest areas are very fragmented across the park areas. Simplify them by creating a separate layer for this land use class. Then, omit the smaller areas, aggregate larger areas, and finally simplify the line geometry, taking into account neighboring objects.

### Creating independent Forest and Residential Layers

1. Select all forest areas of the layer *osm\_landuse*. To do this, use the *Select Layer By Attribute* tool to select and create an SQL query (see picture) or create a rule-based definition query. The land use class for the forest is stored in the attribute value fclass as 'forest.' Execute the selection with *Run*.

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1. RIGHT-CLICK on the *osm\_landuse* layer in the Contents area and then use *Selection > Make Layer from selected Features*  to create a layer with only these forest areas. Rename this layer to '*forest*'.

* Repeat the steps to select the settlement areas with fclass='residential' and rename them to "residential".

### Aggregating Forest Polygons

* To eliminate smaller areas of the new *forest* layer and merge larger areas, use the *Aggregate Polygons* tool.

1. Open the Aggregate Polygons tool using the forest layer as the Input Features.
2. Change the units to m or m² (Meters; Square Meters). The *Aggregation Distance* amalgamates polygons within this certain distance into new polygons. *Minimum Area* defines the minimum area for an aggregated polygon to be maintained. *Minimum Hole Size* sets the minimum size of a polygon hole to be maintained. Feel free to experiment with the values or accept the values suggested here.
3. Execute the aggregation with *Run*.

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### Simplifying Forest Polygons

1. Use the *Simplify Polygon* tool. This simplifies polygon outlines by removing relatively insignificant support points, but retains the essential shape.

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1. You learned about the Douglas-Peucker algorithm in the lecture, but here we use the Zhou-Jones algorithm. This first identifies triangles of an effective area for each support point. Then, using several characteristic values, the determined triangles are weighted according to the flatness, obliquity and curvature of the respective surface. The weighted surfaces determine the distance of their corresponding support points to simplify the polygon outline while retaining as many properties as possible.
2. The *Simplification Tolerance* is the height of a significant triangle defined by three adjacent support points. The further the shape deviates from that of an equilateral triangle, the higher the assigned weighting and the less likely it is to be removed. *Minimum Area* defines the minimum area for a simplified polygon to be kept. Feel free to experiment with the values or use the values suggested here.
3. In the *Handling Topological Errors* drop-down menu, CLICK on *Resolve topological errors*. This activates the *Input Barrier Layers* function we need in Step 6.
4. We do not need a list of removed points. Therefore, the option *Keep collapsed points* can be deactivated.
5. With *Input Barrier Layers,* resulting simplified polygons do not cross its geometry. When simplifying forest areas, the resulting simplified forest polygons do not cross settlement areas, which are defined here with *Residential* as the *Input Barrier Layer*. That means we do not receive spatial overlaps.
6. Execute the geometric simplification with *Run*. Inspect the intermediate result.

### Smoothing Forest Polygons

* The polygon looks very edgy at first. Try to correct this with the *Smooth Polygon* tool.

1. Open the *Smooth Polygon* tool, once again.
2. Take the simplified polygon reduced by support points and apply the Bezier interpolation as a smoothing algorithm. In this process, approximated Bézier curves are superimposed onto the input polygon. (Topological errors do not need to be checked).
3. Execute the smoothing with *Run.* You will see from the result that this generalization produces a representation that is better suited for a smaller scale.
4. Assign a dark green fill colour for the symbolisation of the new forest layer.

## EXAGGERATING WATERCOURSE LINES

* The creeks in the English Garden are to be retained (in general) at the 1:25,000 map scale. The characteristic meandering courses should be emphasised, but should not flow over the settlement areas. Emphasis always includes aspects of simplification. Therefore, the procedure is similar to 8.2.

### Reducing unimportant nodes of the polylines

1. Open the Simplify Line tool.
2. Select *osm\_waterways* as input features. Again, use the *Douglas-Peucker* algorithm. You can set *50 m* as *Simplification Tolerance*. Again, we do not need a list of distant points. Therefore, the option *Keep collapsed points* can be deactivated.

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1. As before, CLICK on *Resolve topological errors on the Handling Topological Errors* drop-down menu.
2. Select the layer *residential* as *Input Barrier Layer* so that the creeks do not overlap the residential area.
3. Execute the geometric simplification with *Run*. Inspect the intermediate result.

### Exaggerating the Creek Meanderings

Although the Douglas-Peucker lake polygon contains the characteristic bends, it is still far too edgy. Remedy this again by smoothing with the *Smooth Line* tool.

1. Open the Smooth Line tool
2. Take the simplified waterways polyline layer and apply *Bezier interpolation* as smoothing algorithm. (Topological errors do not need to be checked).
3. Execute the smoothing with *Run*. You will see from the result that this generalization produces a representation that graphically exaggerates (emphasises) large curves to a certain degree. The inflows to the lake should be preserved.

## TYPIFICATION / DIMENSIONAL COLLAPSE OF UNDERGROUND LINES

* Collapse the (polygon-esque) double line geometry of the underground line on the Ungererstrasse into a single line for our subsequent map.

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1. Open the *Merge Divided Roads* tool. This algorithm generates features with single-lane lines instead of mapped pairs of divided lanes.
2. Select the *osm\_railways* layer as the input feature.
3. Select *code* as *Merge Field* to merge only equal classes of rails and a name for the Output Feature.
4. The other fields can be left blank. Execute the algorithm with *Run*. Inspect the result. With this simple processing of double-track rail routes, not all generalization problems in the data area are solved. However, this tool is sufficient for our 1: 25,000 scaled map.
5. Symbolise the new underground line layer.

## AGGREGATING BUILDINGS

* The buildings are too small for representation at the scale of 1:25,000. Aggregate smaller structures, taking the streets into account. Furthermore, simplify the building footprints by taking the typical rectangular building structure into account.

1. Open the *Aggregate Polygons* tool to eliminate smaller buildings and aggregate larger building areas.
2. Use building layer *osm\_buildings* as *Input Feature*. Change the units to m or m² (Meters; Square Meters) to get a feel for the units. Again, feel free to experiment with the values or accept the suggested values.
3. It is important that you activate the option Preserve orthogonal shape to preserve the perpendicularity and introduce the road layer *osm\_roads* as separating *Barrier Features*.
4. Execute the aggregation with *Run*. Assign a dark grey tone with no outline for the generalised building layer.

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## CLASSIFYING OSM LAYERS

### Classifying Green Spaces

* The green spaces are very heterogeneous. OSM defines green spaces by the classes *park*, *grass*, *scrub* and *recreation\_ground*. These are to be classified as one single class for the 1:25,000 scale. It is not necessary to edit the geometry.

1. Select all green spaces of the *osm\_landuse* layer. Use the *Select Layer By Attribute* tool. You can either create an SQL query or create a rule-based definition query. The land use classes are stored in the attribute value *fclass*. Select all four layers of *park*, *grass*, *scrub* and *recreation\_ground* (use the logical operator "*or*"). Execute the selection.
2. Create a layer from these selected features containing green spaces only. Rename the layer to "*park*". Change the symbology from *Unique Values* to *Single Symbol* and assign an appropriate symbolization.

### Classifying Industrial and Commercial areas

* Commercial and industrial areas are very similar in their use. For a map at a scale of 1:25,000, there is no need to distinguish between them. Create a new layer that combines the classes *industrial* and *commercial* of the layer *osm\_landuse*. Symbolise the new layer.

## SELECTING ROADS AND PATHS

* The entirety of the street and path network cannot be meaningfully at a scale of 1:25,000. Select only the streets, as well as some characteristic paths in the English Garden.

1. Select the path layer *osm\_paths* on the *Contents* pane. Then, CLICK on *Feature Layer > Symbology > Unique Values* to get to the Symbology area. For the *Value Field* you have to select *fclass* to symbolise the layer depending on the path´s class.
2. To symbolise all classes individually would be tedious. To approach the symbolisation in a structured way, remove all values from the list by CLICKING on Remove group . Then CLICK on *Add unlisted values* . In *the select values to add* area, select only the class *track\_grade 5* and confirm with *OK*. This class attribute defines some main paths in the English Garden in the area of the following map.
3. Symbolise these paths as a simple line in a grey tone. Do not assign a colour (*No color*) to *<all other values>* in orderto display the class *track\_grade 5* only.

## DISPLACEMENT OF POINT SYMBOLS

* When looking at the layout of the 1:25,000 map, it is noticeable that the point symbols are sometimes poorly placed. Restrict the positional accuracy within an acceptable margin in order to place the symbols better, especially those of churches and monuments. The symbols should not be piled on top of each other, should not be cut off from the map edge and should be placed logically (e.g. not on the lake). The point symbols should be easy to read.

1. Select the point symbol layer *osm\_pois* (points of interest) on the Contents pane. CLICK *Edit > Modify*. In the Modify Features area CLICK on *Move* . CLICK to select a point symbol. A yellow dot will appear. You can now move it with DRAG and DROP.
2. You can also move the "*Schwabing*" district label with the point symbol layer *osm\_places*. To do this, however, you must first assign a symbolisation for the point so that you can move the corresponding point. Then you can move this point again with *Modify Features > Move* . When the label is positioned, assign the value No colour to the point symbolisation again to make it invisible.
3. When all the necessary symbols have been displaced, save your geometric changes with *Edit > Save* .

## ADJUSTING THE VISUAL ORDER OF THE LAYERS

1. Switch on all the layers in the contents area that you need and toggle off all those layers that you do not need.
2. Adapt the symbolization of required layers if necessary.
3. Finally, adjust the order of the layers in the Contents pane. Check the generalization result in the layout *1:25,000*. When viewing the layout, make sure that the view is at 100% (i.e. not reduced or enlarged).
4. Under Share > Export > Layout  , you can print a PDF of your generalized subsequent map at a scale of 1:25,000.

## SUBMITTING THE PDF RESULT

You can upload the generalized 1: 25,000 result map onto Moodle. Please upload the PDF only.

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