POSSIBILITY AND CONSTRAINT PARAMETERS FOR AUTOMATED GENERALIZATION OF MULTI – SCALE BASE MAPS

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ABSTRACT

Map generalization plays an important role in map-making process. Map generalization depends on many factors such as purpose, geographic scope, thematic, map scale... and therefore it remains one of the challenging issues in Cartography. This paper discusses the constraint parameters and process of cartographic generalization from map data at 1:2000 to map data at smaller scale such as 1:5,000, 1:10,000, 1:25,000, 1:50,000 and 1:100,000. These constraint parameters are indentified by applying cartographic principles and using experimental procedures with generalization toolset in ArcGIS 10. Defined constraint parameters are then put in cartographic generalization for base maps of Ho Chi Minh City in order to verify their rationalities.

Research result shows that, using right parameters and GIS cartographic generalization tools could provide good way to generalize and create base map products fast, efficient and reasonable. It also provides useful information for further research in automated map generalization and in creating multi-scale, multi-purpose map database.

Keywords: Map generalization, multi - scale map, topographical map.

1. INTRODUCTION

Map generalization plays an important role in the map-making process and it remains one of the challenging issues in Cartography nowadays because there are a lot of natural and social economic factors on the Earth's surface and they are not able to- be shown all-in-one on the map.

Generalization process can be performed manually and automatically. The automated generalization, carried out by computer with or without human interaction [1]. Many algorithms for automated map generalization were proposed such as Douglas-Peucker, Walking, the ATM filtering, optimization simplification, Visvalingham- Whyatt, etc, but final solution hasn’t been
yet [2]. Also other than the constraints, map specifications were used to model the constraints in order to produce cartographically aesthetic product.

Currently, some companies have developed the GIS softwares, tools for automated map generalization. One of the most popular is the toolset in ESRI’s ArcGIS software. These tools provide certain utilities for map edition and also provide the flexibility of using different approaches for map generalization [3], [4]. However, these tools only can be used to generalize independent objects. So, for the best results, editors have to combine several tools together in a process with pre-defined order and this requires a lot of cartographic knowledge as well as editors’ experiences.

In recent years, the needs of multi – scale base maps are increasing to serve different activities such as socio- economic development, environmental protection, resource assessment, land administration and land changed evaluation… This paper focuses on studying constraint parameters and conducting experiments for creating a multi-scale base maps system from scale of 1: 2.000 to scale of 1: 100.000 using combined tools in ArcGIS 10 software.

2. METHODOLOGY

Data: Main data source is topographic maps at scale 1:2000, which are in VN-2000 datum. These data had been processed with Microstation software to be suitable for further map generalization procedure.

Research and identify constraint parameters: For creating multi-scale base maps (1:5.000-1:100.000) from original data maps at scale of 1:2.000, we must identify the constraints, specifications, standards for generalization at each scale level.

These parameters are determined, based on cartographer’s experiences, constraints- specifications, standards of symbols, visual assessment of the results on screen and prints,
references to minimum sizes, distribution and density on mapping space, control of generalization process through appropriate tolerances/parameters.

**Process and methods:** Based on defined generalization constraint parameters, cartographic generalization processes are implemented. Defined processes are performed by generalization toolset in ArcGIS, with data in HCMC (shore lines, roads and building data layers) for verifying

### 3. RESULTS AND DISCUSSION

#### 3.1. Defining constraint parameters for Automated Generalization of multi-scale base maps

##### 3.1.1. The building generalization constraint parameters.

On maps at scale 1:25 000 and larger blocks are drawn with the accurate size and shape. At smaller scale maps, buildings and blocks are represented in point symbols, buildings in dense area are eliminated, orientable buildings are retained, maintaining building density and distribution. Parameters must be defined for each scale level in order to merge or remove building blocks [5].

![Diagram](image)

**Figure 2.** The graphic limits of buildings and blocks.

The principle of automated generalization is shown in the set of the generalization constraint parameters, these indicators must be suitable to display the geographic features in the given scale. If the object does not fit those limits, it can be changed or cancelled. Based on graphic limits, a fixed paper size on various scale, and cartographic experience in the map-making process, we can define building generalization constraint parameters.

<table>
<thead>
<tr>
<th>Constraint parameters</th>
<th>The corresponding size in reality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:2000</td>
</tr>
<tr>
<td>a(m)</td>
<td>0.6</td>
</tr>
<tr>
<td>b(m)</td>
<td>0.6</td>
</tr>
<tr>
<td>c(m)</td>
<td>0.6</td>
</tr>
<tr>
<td>d(m)</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Possibility and constraint parameters for automated generalization of multi-scale base maps

<table>
<thead>
<tr>
<th>5</th>
<th>e(m)</th>
<th>0.3</th>
<th>0.75</th>
<th>1.5</th>
<th>3.75</th>
<th>7.5</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>P (m²)</td>
<td>1.8</td>
<td>4.5</td>
<td>9</td>
<td>22.5</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>S(m²)</td>
<td>16</td>
<td>40</td>
<td>80</td>
<td>200</td>
<td>400</td>
<td>800</td>
</tr>
</tbody>
</table>

Constraint parameters are guidelines for the generalization of specific features, which determine the use of appropriate generalization algorithms (operators). Cartographic constraints can be set, such as minimum sizes of buildings, minimum distance between buildings, minimum distance between buildings and roads, keeping building alignment and spatial distribution of buildings. Editors can use these in order to produce cartographically aesthetic product.

3.1.2. The road generalization constraint parameters.

The popular simplifying line algorithm is Douglas-Peucker. This algorithm is then used to develop two the algorithms POINT_REMOVE and BEND_SIMPLIFY. BEND_SIMPLIFY obtained results keep the original shape with geometric quality better than Point remove, however, this process takes more time. Based on map generalization algorithms and practical experiences we can define road generalization constraint parameters as following.

Table 2. Road generalization constraint parameters.

<table>
<thead>
<tr>
<th>Constraint parameters</th>
<th>The corresponding size in reality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:2000</td>
</tr>
<tr>
<td>Minimal length of an object (m)</td>
<td>20</td>
</tr>
<tr>
<td>Minimal tolerance (m)</td>
<td>1.0</td>
</tr>
<tr>
<td>Width of two-way (m)</td>
<td>1.6</td>
</tr>
<tr>
<td>Width of one-way (m)</td>
<td>1.2</td>
</tr>
</tbody>
</table>

3.1.3. Shoreline generalization constraint parameters

In generalizing shoreline considers shape, structure, density, distribution and graphic characteristics. The shape of the coastline is represented in the most detailed level. If bend baseline is smaller than 0.5 mm², it can be canceled, the small and important details are retained and enlarged. Islands, rivers are selected, adjacent islands can be drawn with the same shoreline.

Table 3. Shoreline generalization constraint parameters.

<table>
<thead>
<tr>
<th>Constraint parameters</th>
<th>The corresponding size in reality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:2000</td>
</tr>
<tr>
<td>Minimal length of a river (m)</td>
<td>20</td>
</tr>
<tr>
<td>Minimal width of a river (m)</td>
<td>6</td>
</tr>
<tr>
<td>Minimal bend of a shoreline (m)</td>
<td>1</td>
</tr>
<tr>
<td>Minimal area of a polygon (m²)</td>
<td>8</td>
</tr>
</tbody>
</table>
Shorelines generalization allows removing small bends that are not located in an important position on the maps and diameters are smaller than 0.5 mm. The specific small bends should be retained and enlarged to the 0.5 mm - 0.6 mm size, keeping shape of bends.

### 3.2. Applying ArcGIS 10 for generalizing spatial geographic objects on maps

This paper discusses the process of cartographic generalization base map data at source scale of 1:2.000 using generalization tools in ArcGIS 10. The end products were multi-scale base maps. The process of cartographic generalization in this range is similar to the process of different scale transition and base on map sheets. The process is shown on the figure below.

![Figure 3: Overview of the different scale transitions.](image)

The study area is a part of HCM city - Viet Nam, represented by 4 topographical map sheets at the scales 1:2.000 which cover an area of one sheet of scale 1:5.000 or area represented by 256 topographical map sheets at the scales 1:5.000 which cover an area of one sheet of scale 1:100.000. Generalization was carried out on base vector data at scale of 1:2.000 and generalised to scales of 1:5.000, 1: 10.000, 1:25.000, 1:50.000 and 1:100.000.

#### 3.2.1. Buildings generalization

Buildings generalization were applied by selecting building layers to be generalized and then operations algorithms such as aggregation, and simplification were chosen. ArcGIS Generalization toolset can be applied to an entire feature class or only for selected objects and can also be combined to achieve the results. Two approaches were tested [6].
Generalization A is used to generalize buildings and blocks on larger scale maps, that are represented and maintained their essential shape and size. Generalization B is used to objects on smaller scale maps that are not represented and maintained their essential shape and size, so replaced them with point symbols.

### 3.2.2. Roads Generalization

Road generalization was done through deleting or selective pruning or checking in the layout or data visualization in the suggested generalization scales. If trails have large length and width but not significant "lifeline", they can be changed or canceled. Roads must be classified clearly before generalization for convenient in the process of using the tools.

Common tools used to generalize road layers in ArcGIS software are Simply Line, Collapse Dual to Centerline. Most of the foot paths are eliminated from the display using collapse Dual lines to centreline generalization tool. It is noticeable that most foot paths are retained where there are junction points unlike where there are no junctions.

![Simply Line](image1)

**3.2.3. Shoreline Generalization**

In shoreline generalization, two line simplification criteria were used: simplification and smoothing. Simplification was by bendSimplify and point remove and smoothing was done using smooth line. The smooth line tool does not require tolerance specification and hence can be used in all scales.

Shore line simplification was based on 5 meters offset at scale of 1:10,000, 50 meters offset at scale of 1:50,000 and 100 meters offset at scale of 1:100,000. The data was then checked and resolved topographical errors.

### 3.2.4. Testing, and Evaluation Generalization Results

Input maps must be classified, edited, debugged, and completed before carrying out generalization. Base on constraint parameters were given in table 1, 2 and 3, approaches were shown above. Then, using toolset in ArcGIS 10 software to generalize data from large scale to small scale.

![Maps at the scale of 1:5.000 and 1:10.000.](image2)

**(a). 1: 5.000**

**Figure 4. Maps at the scale of 1:5.000 and 1:10.000.**
For scale of 1:5000, buildings were converted into block if their distances are at least 1.5 m in reality, buildings are removed if their area is smaller than 40 m², derives centerlines from dual-line (or double-line). Results shown at the scale of 1:5000 don’t have conflicts of symbolized objects.

For scale of 1:10000, buildings or blocks were aggregated within a specified distance of each other into new blocks, simplified the boundary of blocks, roads, shorelines while maintaining their essential shape and size, collapsed road detail and merge divided roads. From these results and solutions, we can implement generalizations quickly to create the scale maps 1:25000, 1:50000, 1:100000.

![Figure 3](image3.png)

Building generalization by simplifying was not done at the scale 1:100000 because of inability to preserve areal size of features. Aggregation and erase points are used instead for displaying aggregated, converted to points and those in built up areas.

From the results obtained it indicates that, GIS cartographic generalization provides a good opportunity to generalize large scale data. The process is fast and efficient and would enable one to obtain updated detailed maps up to two times.

4. CONCLUSION

Based on the result of this research and experiences in editing map, then using the available toolset in ArcGIS 10 software, we have successfully tested on the creation of multi-scale base maps. The results of target maps are reasonable, and afford the requirements.

Multi-scale base maps are needed for many different purposes such as social-economic development and environmental protection, resource assessment, sustainable development, adapting with climate change and sea-level rise... To create the multi-scale base maps that meet multiple purposes, the solution is to use large scale maps that have been updated. The map researchers as well as researchers in other fields can use these criteria and solutions, combine with the available tools in ArcGIS to generalize maps automatically. This is also the basic to be able to propose and design database and automated tools to retrieve multi-scale and multi-purpose maps in the future.

REFERENCES


