Resolving Graphic Conflict in Scale-Reduced Maps Using Automated Generalisation: Refining the Simulated Annealing Approach

Nathan Thomas
Mark Ware, Chris Jones
nthomas4@glam.ac.uk;jmware@glam.ac.uk

School of Computing
University of Glamorgan, Wales, U.K.

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The Problem

- The Ordnance Survey (UK Mapping Agency) has presented us with a series of map related graphic-conflict problems that needs addressing.

- These graphic-conflict problems need to be solved to allow the O.S. to develop new types of map scales (PDA’s, In-car navigation systems etc) and to speed-up traditional map making methods.
What are these graphic-related problems?

Example 1 – Master Map Data & OSCAR (Roads)

Data supplied by the O.S. [Region: Isle of Wight]
What are these graphic-related problems?

Example 2 – Symbolise Roads

Data supplied by the O.S. [Region: Isle of Wight]
A Solution?

Which approach have I chosen for my PhD? & Why?

• Previous Simulated Annealing work that made use of displacement.
• Why? We already had a system in place that worked to some degree.

Why can’t the O.S. make use of this previous work?

• Previous work is limited and requires expansion.
• This ‘expansion’ is the focal point of the PhD Project.
An overview of the original simulated annealing system: Mark Ware and Chris Jones (1998)

- Displacement Operator
- Trial Positions
- Cost Function
- Simulated Annealing

- Implemented in C code.

The main research question being addressed by this project is:

“To what extent can an optimisation technique such as Simulated Annealing be used as a Process Control to automate the generalisation process?”

*Practical problem will be to apply the modified S.A. to O.S. large-scale datasets and a means of evaluation.*
How can we make improvements to the original S.A.?

*Initial investigation revealed the following:*

1. S.A. was slow.
2. Not all conflict could be resolved using displacement.
3. Additional problems were introduced as a result of displacement (Disruption to High Order Features)
4. Problems with the use of discrete trial positions.
Extending S.A.

Execution Time Improvements

We needed to reduce the number of realisations that were generated and tested.

How is it achieved?

• Partition the dataset into segments and apply the S.A. to each individual region with a specific S.A. Schedule.
• Incorporate a Two-stage Annealing approach.
• Other iterative improvement algorithms were also tested (Gradient Descent, Genetic)
Extending S.A.

Execution Time Improvements - Results

<table>
<thead>
<tr>
<th>Results</th>
<th>average number of tests</th>
<th>average execution time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original (sun)</td>
<td>342302.2</td>
<td>39.67</td>
</tr>
<tr>
<td>800MHz PC</td>
<td>302840.0</td>
<td>11.83</td>
</tr>
<tr>
<td>partitioned</td>
<td>236935.6</td>
<td>9.73</td>
</tr>
<tr>
<td>two-stage</td>
<td>150749.2</td>
<td>6.13</td>
</tr>
<tr>
<td>combined</td>
<td>102539.4</td>
<td>4.1</td>
</tr>
</tbody>
</table>
How can we attempt to resolve the remaining conflict?

Incorporate Additional Operators

• Enlargement
• Reduction*
• Deletion**
• Plus others..

Emphasis is not on reinventing the wheel, but whether or not S.A. can handle additional operators.

*Only applied to large buildings where reduction is permitted
** Rarely used (only as last resort)
Applying additional Operators to previous problem
Solution
Grouping Features
Further Problems - Disruption to High Order Features

- fragmentation
- misalignment
Solution

- group polygons
- apply modification operators to groups
Extending S.A. – Grouping Features

Polygon grouping based on
- distance
- proximity to roads
- etc
Extending S.A. – Grouping Features

Solution

Before

After
Further problems with existing S.A.

Use of discrete Trial Positions

Not all conflict can be solved adequately, simply due to the fact that there does not exist a suitable trial position for the object to move to.

E.g.

![Diagram showing three stages of a process involving trial positions](image)
Extending S.A. – Further problems

Use of discrete Trial Positions with O.S. MasterMap data

Discrete

too much displacement

too much reduction
Extending S.A. – Further problems

Solutions?

• Extend the search space by adding more trial positions

  e.g.

  • There might still not exist an adequate trial position
Another Solution?

• Make use of a continuous search space instead of a discrete one.

i.e.
Replace

pick object at random
pick trial position at random

with

pick object at random
pick generalization operator at random
generate random parameters for operator
Extending S.A. – Further problems

Use of a continuous search space applied to O.S. MasterMap dataset
Extending S.A. – Further problems

Comparison – Discrete vs Continuous

Discrete

Continuous
Remaining Work

• Apply S.A. to other polygon feature classes (e.g. inland water features, ponds, lakes etc)

• Investigation into adapting S.A. for use with Linear features (e.g. Roads, Rivers, Railways)

• Evaluation (More experiments for PhD)
To Conclude:

“To what extent can an optimisation technique such as Simulated Annealing be used as a Process Control to automate the generalisation process?”

1. We have significantly decreased the time it takes for S.A. to run.
2. Shown additional operators can be added to S.A. to resolve any remaining graphic conflict.
3. Solved disruption to high order features by investigating the use of grouping features as a pre-process to S.A.
4. Presented a solution that makes use of Continuous Search Space.
5. New S.A. is now integrated by means of a DLL into ESRI’s ARCGIS software.
References:

Thomas, N. and Ware, J.M. 2003 “Resolving Graphic Conflict in Scale Reduced Maps – Refining the Simulated Annealing Approach”, GISRUK 2003, City University, London, UK

