Resolving Graphic Conflict in Scale-Reduced Maps Using Automated Generalisation:

Refining the Simulated Annealing Approach

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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.**

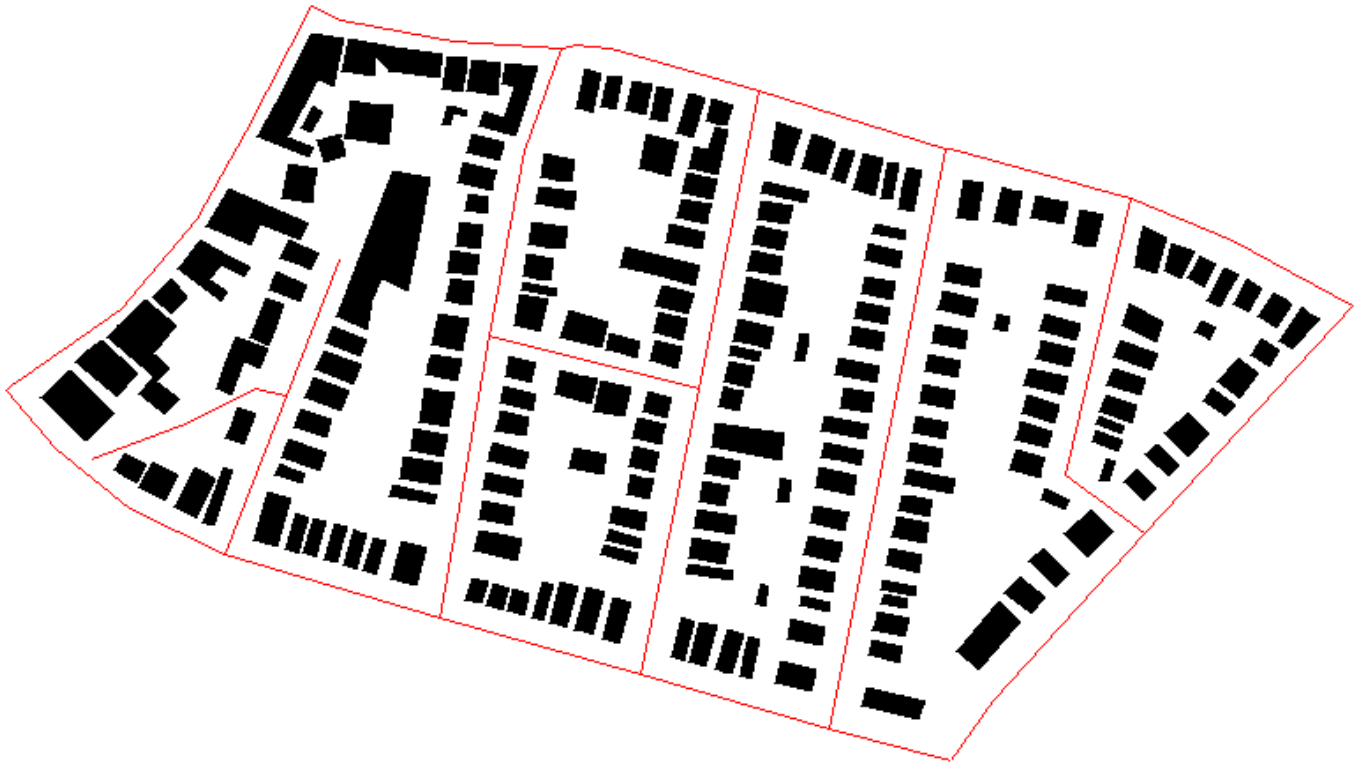
- **These graphic-conflict problems need to be solved to allow the O.S. to develop new types of map scales (PDA's, In-car navigation systems etc) and to speed-up traditional map making methods.**

Handheld PDA

In-car navigation system

What are these graphic-related problems?

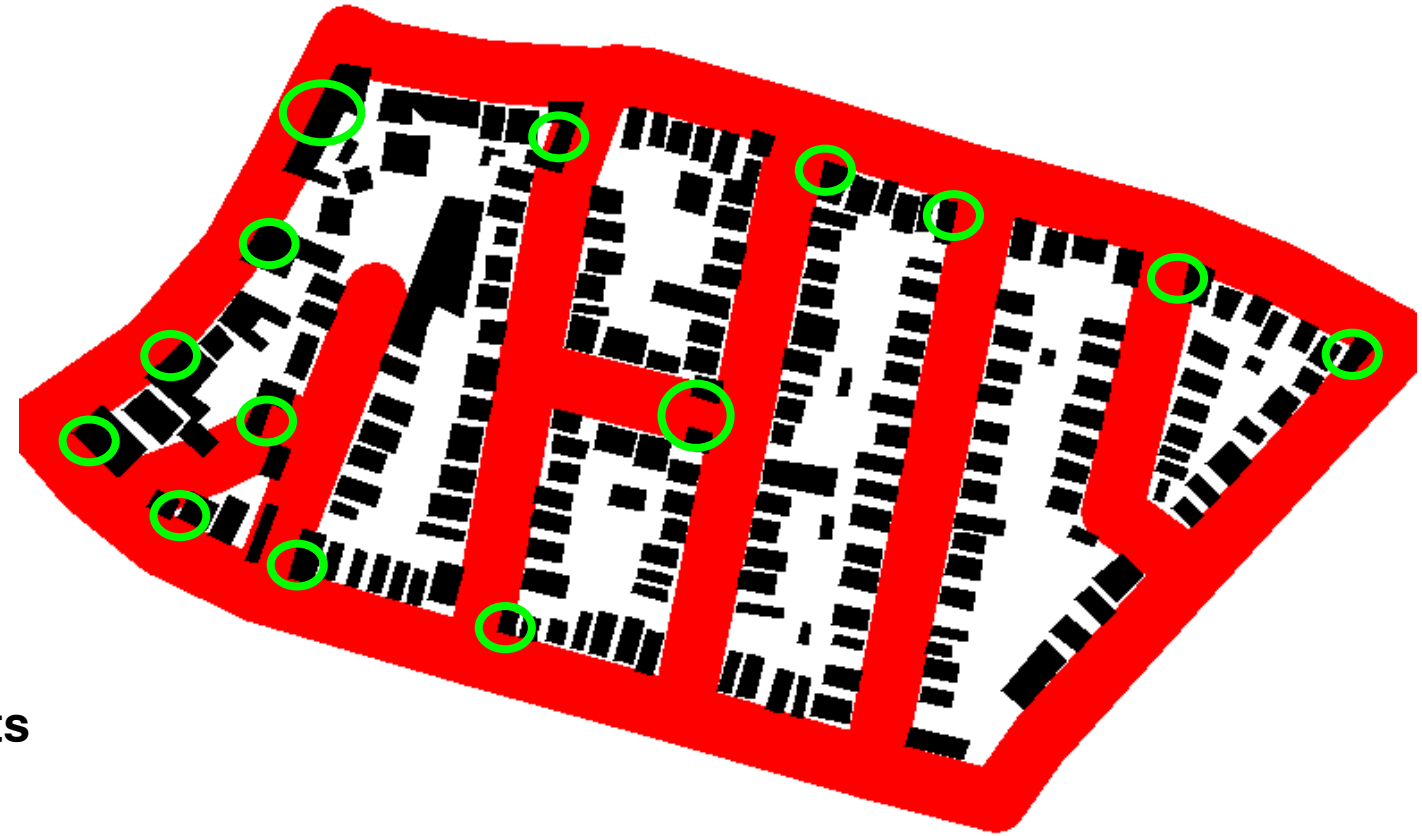
Example 1 – Master Map Data & OSCAR (Roads)



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

What are these graphic-related problems?

Example 2 – Symbolise Roads



Conflicts

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.

Graphic Conflict Reduction using S.A.

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.**

Ware, J.M., Jones, C.B., 1998, "Conflict reduction in map generalisation using iterative improvement", GeoInformatica 2:4, 383-407

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.**

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)**

Execution Time Improvements - Results

Results	average number of tests	average execution time in seconds
Original (sun)	342302.2	39.67
800MHz PC	302840.0	11.83
partitioned	236935.6	9.73
two-stage	150749.2	6.13
combined	102539.4	4.1

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)***

Extending S.A. – Original Problem

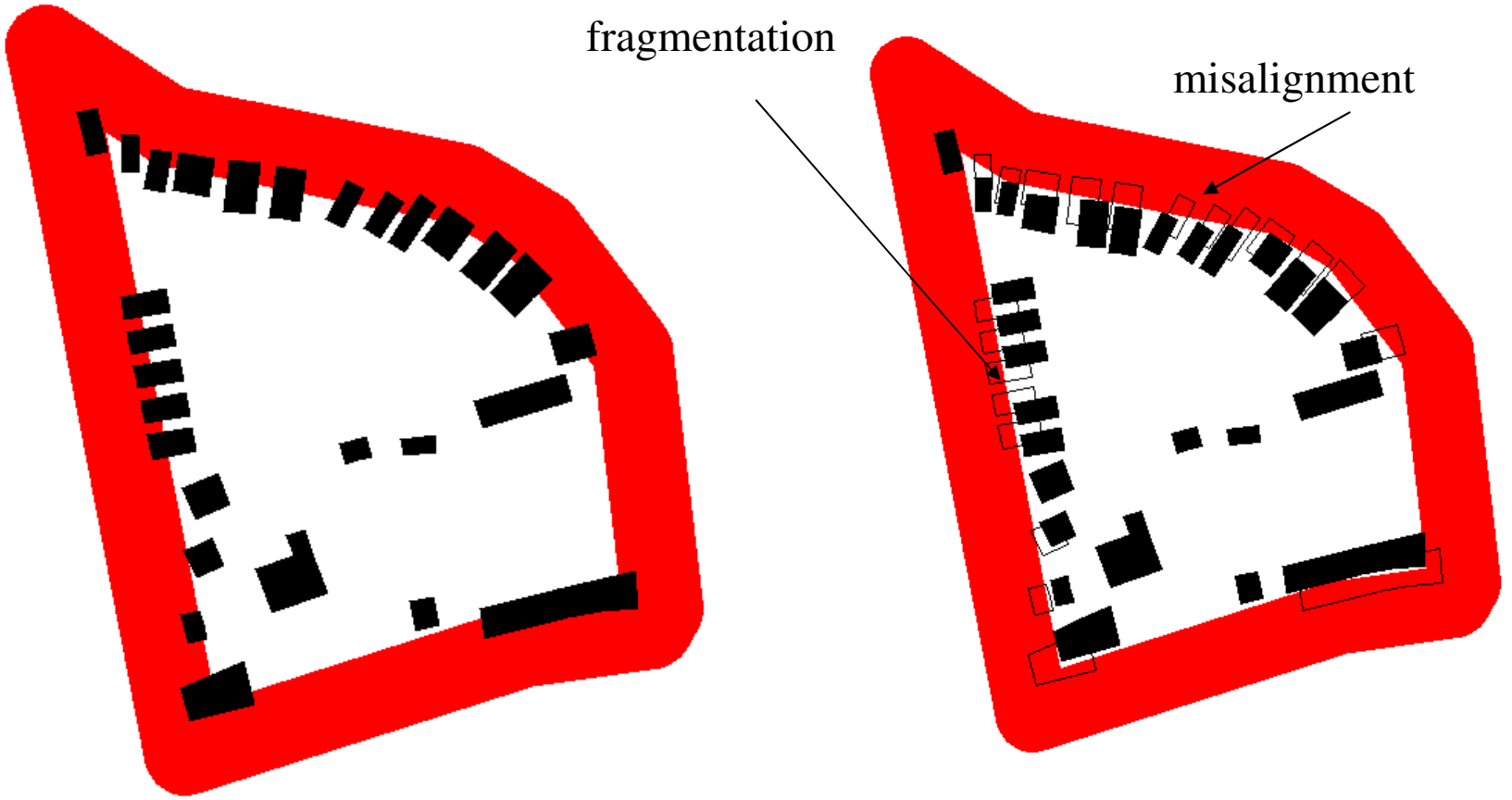
Applying additional Operators to previous problem

Extending S.A. – Solution to previous problem

Solution

Grouping Features

Further Problems - Disruption to High Order Features



Extending S.A. – Grouping Features

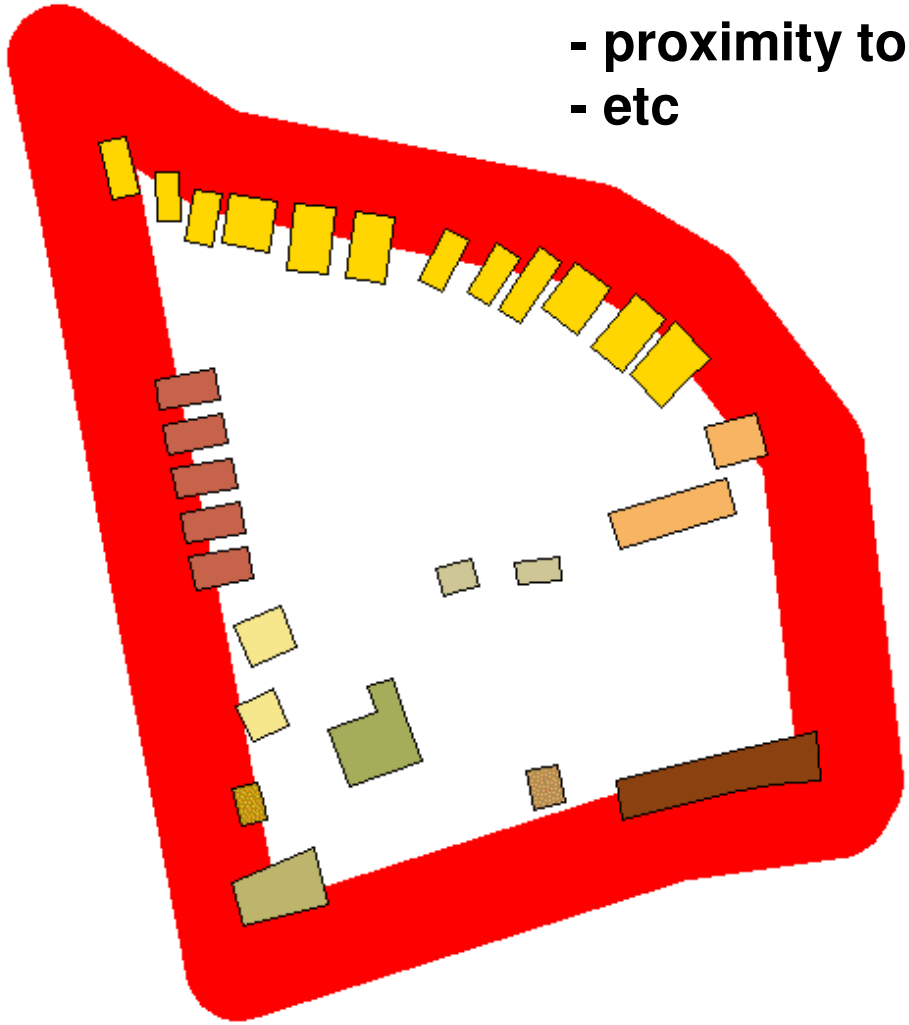
Solution

- group polygons
- apply modification operators to groups

Extending S.A. – Grouping Features

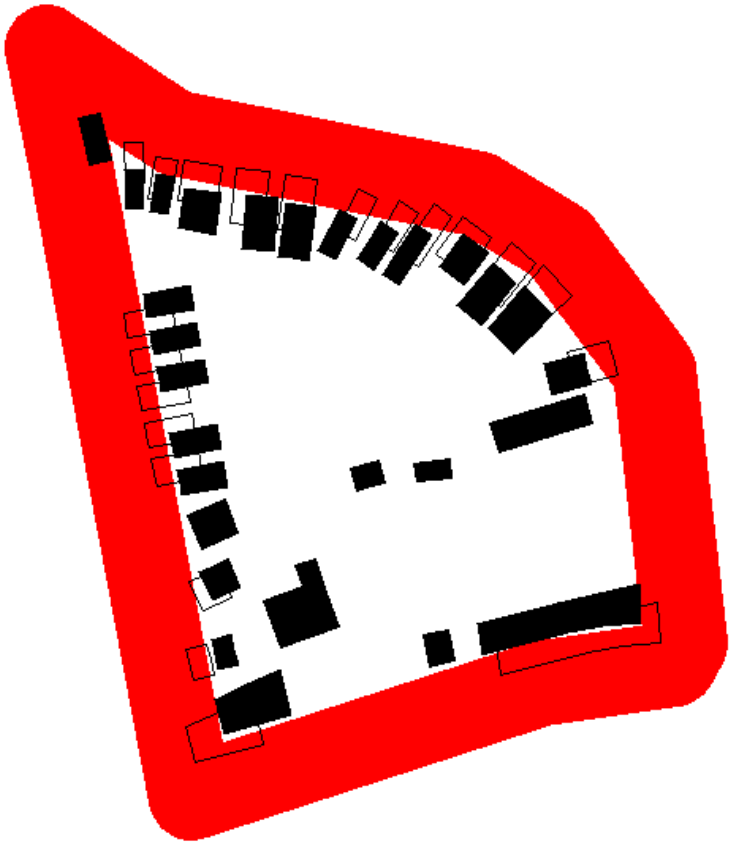
Polygon grouping based on

- distance
- proximity to roads
- etc

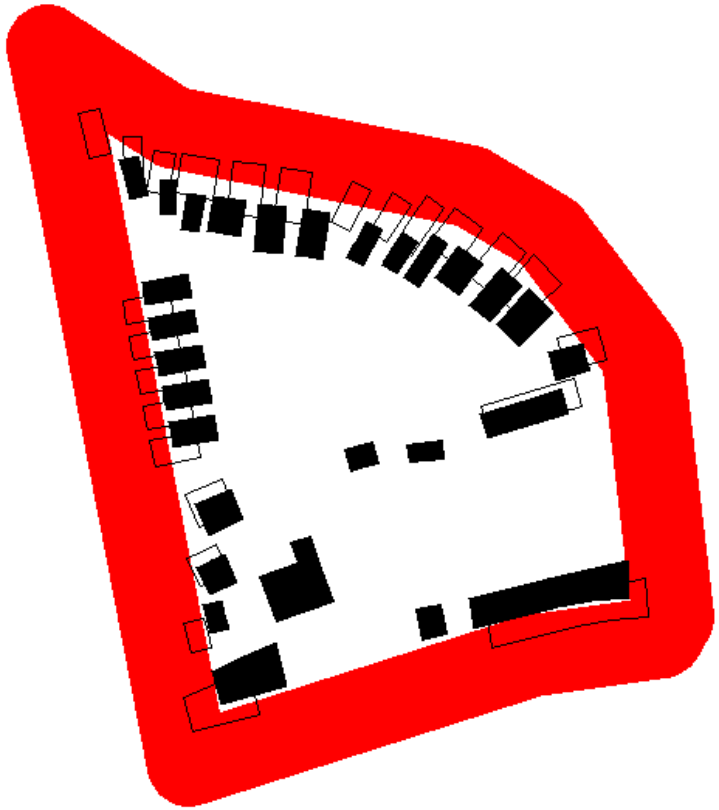


Extending S.A. – Grouping Features

Solution



Before



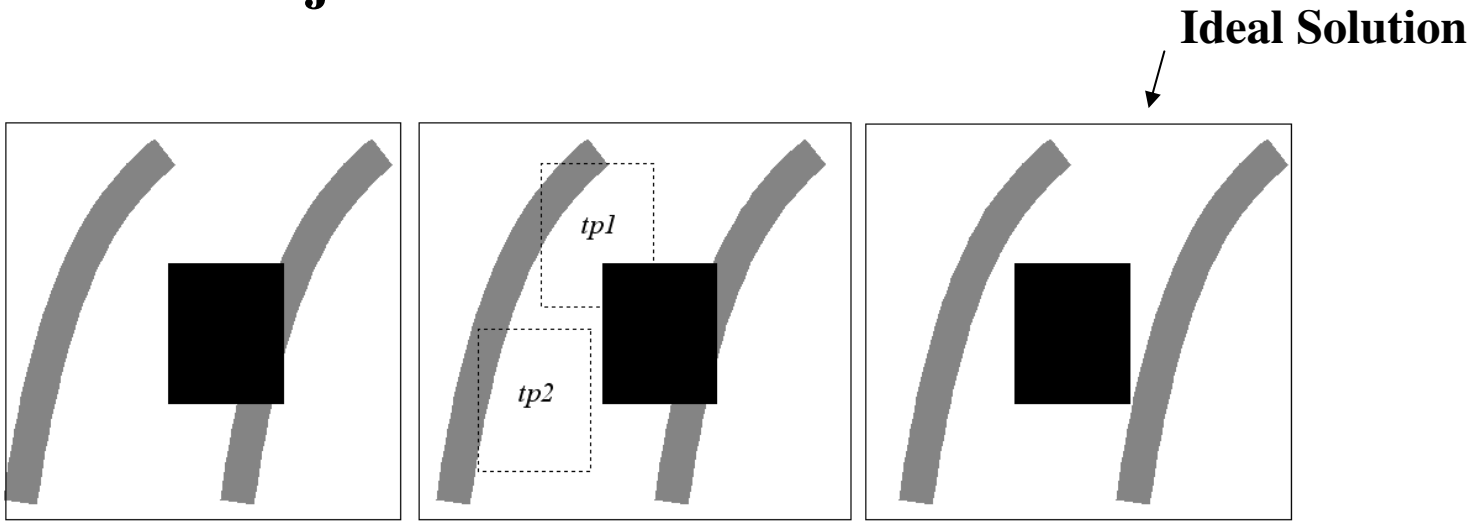
After

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.

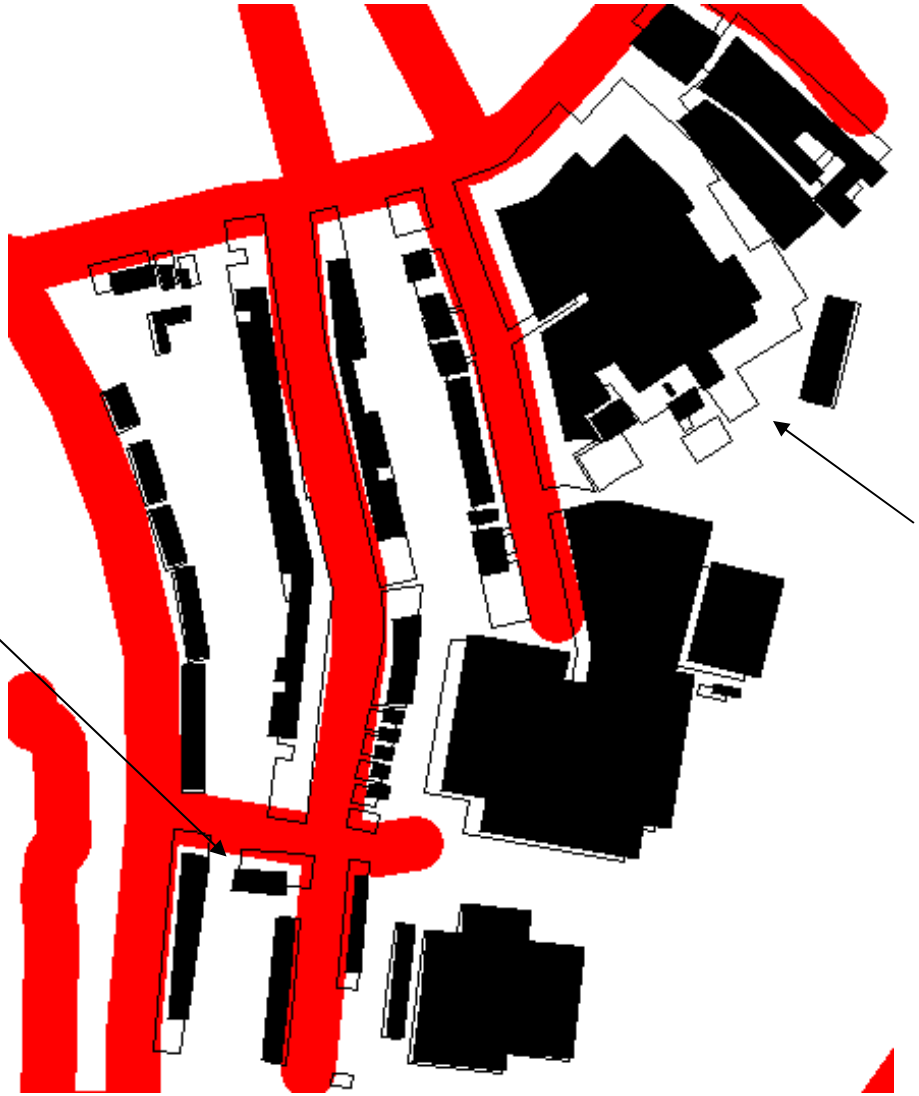
E.g.



Extending S.A. – Further problems

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

Discrete



too much displacement

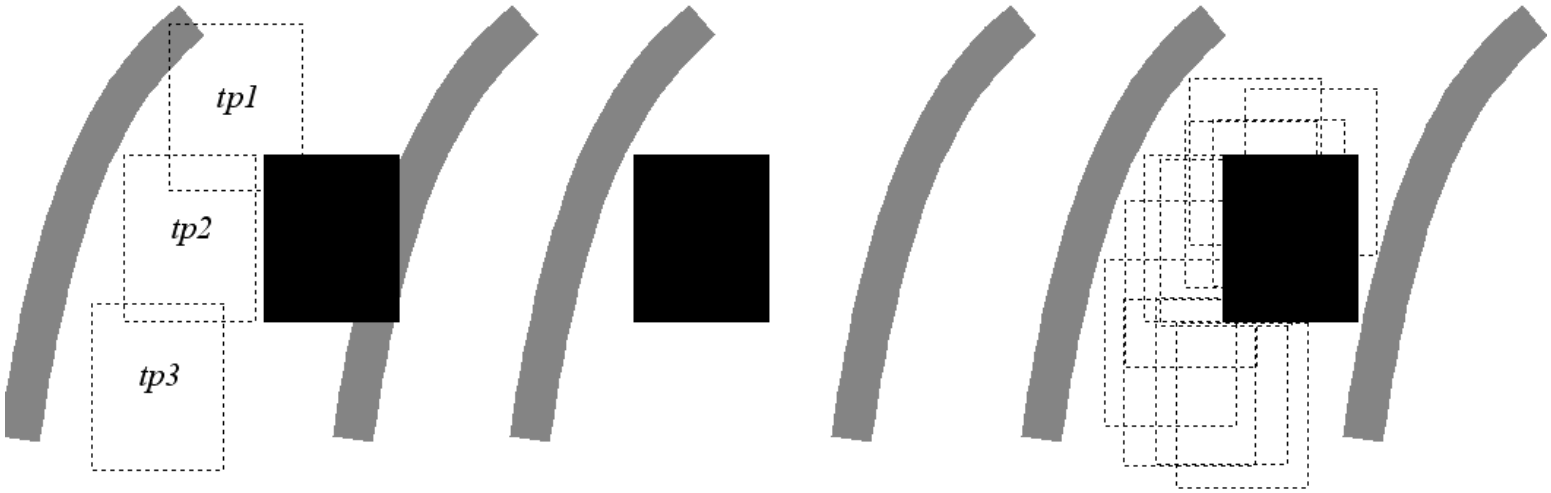
too much reduction

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?

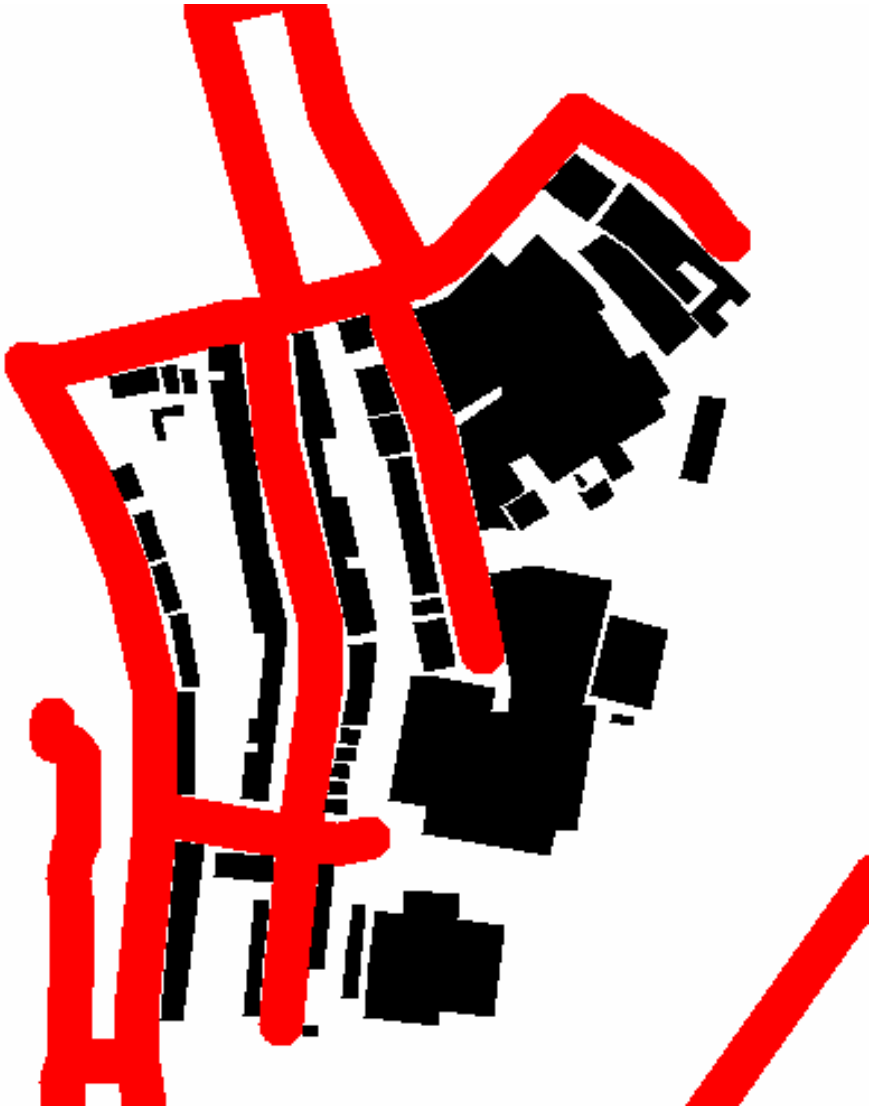
- Make use of a continuous search space instead of a discrete one.

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

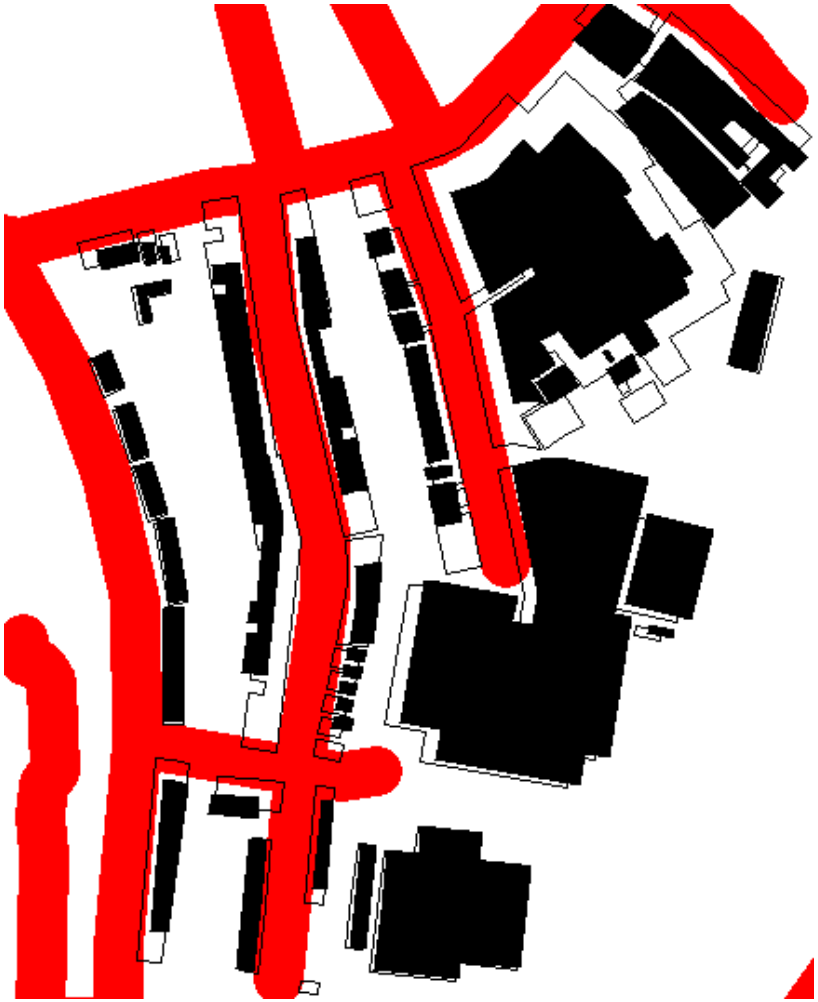
Continuous



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

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Ware, J.M., Thomas, N. and Jones, C.B., 2002, "Map Generalization by Iterative Improvement: Maintaining Feature Alignment", in Proceedings of GIScience 2002, Sept 2002, Boulder, pages 201-203

Ware, J.M., Jones, C.B. and Thomas, N., 2001, "Map Generalization, Object Displacement and Simulated Annealing: Two Techniques for Execution Time Improvement", Proceedings of GIS Research UK 2001 Conference (GISRUK '01) University of Glamorgan, April 2001, pages 36-38