Toward Analytical Cadastre – Case Studies based on Genetic Algorithms

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Outline

Introduction
GAs Overview
Implementation – Cadastral Analogy
Case Studies
Summary & Future Work
Introduction

Society’s demands and necessities are constantly changing

The current cadastral systems are of an analogical nature

A reliable land administration system is required

The existing graphical system requires re-engineering
Introduction cont.

- Transition to analytical cadastre has given rise to much research
- The common practice is the Least Square (LS) method
- The current techniques are mainly analytical and straightforward
Genetic Algorithms (GAs) Overview

A biological optimization

Characteristics:

- stochastic method
- founded on evolutionary ideas and Darwin's principles of selection and survival of the fittest
- a natural selection which operates on a variety of candidate solutions – chromosomes (individuals)

GAs Overview cont. - Generic Framework

- Encode the given problem
- Create the first/next population
- Evaluate (grade) the initial/current individuals by assigning a fitness value
- Create the next (new) population by applying variation-inducing operators: selection, crossover and mutation
GAs Overview cont. – Genetic operators

_Selection_

- Two parent chromosomes are selected from a population according to their _fitness value_
- **Guiding principle – selection of the fittest**
  - Superior individuals are of a higher probability to be selected (survive)
- **Selection method – roulette wheel selection**
  - Roulette slot’s size is determined by the fitness value

**Example**

<table>
<thead>
<tr>
<th>Number of individual</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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</thead>
<tbody>
<tr>
<td>fitness value</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
<td>0.0</td>
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<tr>
<td>selection probability</td>
<td>0.18</td>
<td>0.16</td>
<td>0.15</td>
<td>0.13</td>
<td>0.11</td>
<td>0.09</td>
<td>0.07</td>
<td>0.06</td>
<td>0.03</td>
<td>0.02</td>
<td>0.0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>trial 4</th>
<th>trial 2</th>
<th>trial 6</th>
<th>trial 5</th>
<th>trial 1</th>
<th>trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>individual</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>0.0</td>
<td>0.18</td>
<td>0.34</td>
<td>0.49</td>
<td>0.62</td>
<td>0.73</td>
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</table>
GAs Overview cont. - Genetic operators

- **Crossover**
  - Two *offspring* are created

| Parents chromosomes | children chromosomes |

- **Mutation**
  - The new offspring genes are changed randomly to ensure diversity
Implementation – Cadastral Analogy

- **Each individual** - vector of turning points coordinates

- **Parcels’ areas, lines and pairs of lines** - provide the cadastral and geometrical constraints

- **Objective function** - minimizes the differences between the actual and the requested values

- **With each generation** - vectors values are altered

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Implementation – Cadastral Analogy cont.

- **Cadastral Conditions:**
  - **Objective function** – calculated and registered areas
  - **Fitness function** - parcel size determines weight

- **Geometrical Conditions:**
  - **Objective function** - turning point angles, line segment lengths, perpendicular distances
  - **Fitness function** - number of points and total lines’ lengths dictate weight

- **Total Grade**
Implementation - Cadastral Analogy

A Successive Generation:
- Parent selection - Tournament method
- Crossover
- Process repetition
- Averaging
- Mutation
Introduction

GAs Overview

Implementation – Cadastral Analogy

Case Studies

Summary & Future Work

Case Studies

Simulations on synthetic data

Case Studies based on legitimate parcellation plans (alternative solution)

Features considered:
- number of parcels
- parcels’ shapes and sizes
- lines’ topology
- numerical ratio
Case Studies cont. - Figures

Case Studies cont.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ex. #1</th>
<th>Ex. #2</th>
<th>Ex. #3</th>
<th>Ex. #4</th>
<th>Ex. #5</th>
<th>Ex. #6</th>
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</thead>
<tbody>
<tr>
<td>No. of Constraints</td>
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<tr>
<td>Parcels</td>
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<td>18</td>
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<td>25</td>
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<tr>
<td>Straight Lines</td>
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<td>2</td>
<td>7</td>
<td>5</td>
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<td>Pairs of Lines</td>
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<td>1</td>
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### Case Studies cont. – Results Analyses

<table>
<thead>
<tr>
<th>Parameters [m]</th>
<th>Example A</th>
<th>Example B</th>
<th>Example C</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Initial</td>
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<tr>
<td>$\text{Mean}_{\sigma_X}$</td>
<td>0.078</td>
<td>0.002</td>
<td>0.122</td>
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<tr>
<td>$\text{Mean}_{\sigma_Y}$</td>
<td>0.076</td>
<td>0.002</td>
<td>0.122</td>
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<tr>
<td>$\text{Max}_{\sigma_X}$</td>
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<td>0.010</td>
<td>0.305</td>
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<tr>
<td>$\text{Max}_{\sigma_Y}$</td>
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<td>$\text{Max}_{\Delta X}$</td>
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<td>$\text{Max}_{\Delta Y}$</td>
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<tr>
<td>$\text{Min}_{\Delta X}$</td>
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<td>-0.803</td>
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<tr>
<td>$\text{Min}_{\Delta Y}$</td>
<td>-0.837</td>
<td>-0.049</td>
<td>-0.874</td>
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</tbody>
</table>
Case Studies cont. – Results Analyses

Coordinates’ Distributions Ex. A

Final Coordinates’ Distribution

Initial Coordinates’ Distribution

Case Studies cont. – Results Analyses

Coordinates’ Differences Distributions Ex. A

Final Coordinates’ Differences Distribution

Initial Coordinates’ Differences Distribution
Case Studies cont. – Results Analyses

Area Difference Distribution - Ex. A

<table>
<thead>
<tr>
<th>Source Data</th>
<th>GAs’ Solution</th>
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<tbody>
<tr>
<td><img src="Image1" alt="Graph 1" /></td>
<td><img src="Image2" alt="Graph 2" /></td>
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Case Studies cont. – Results Analyses

Coordinates’ Distributions Ex. B

<table>
<thead>
<tr>
<th>Initial Coordinates’ Distribution</th>
<th>Final Coordinates’ Distribution</th>
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</thead>
<tbody>
<tr>
<td><img src="Image3" alt="Graph 3" /></td>
<td><img src="Image4" alt="Graph 4" /></td>
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Case Studies cont. – Results Analyses

Area Difference Distribution - Ex. B

- Source Data
- GAs’ Solution

Case Studies cont. – Results Analyses

Coordinates’ Distributions Ex. C

- Initial Coordinates’ Distribution
- Final Coordinates’ Distribution
Case Studies cont. – Results Analyses

Area Difference Distribution - Ex. C

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GAs Overview
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Summary & Future Work
Summary & Future Work

- GAs - a new approach for achieving homogeneous coordinates
- GAs imitate the natural process of evolving solutions
- Several case of different characteristics were presented

Summary & Future Work cont.

- The method provides very promising results

Future Objectives:
- Dealing with more complex situations
- Integrating additional conditions
- Working with adjacent blocks