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***

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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*

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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

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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)*

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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***

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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

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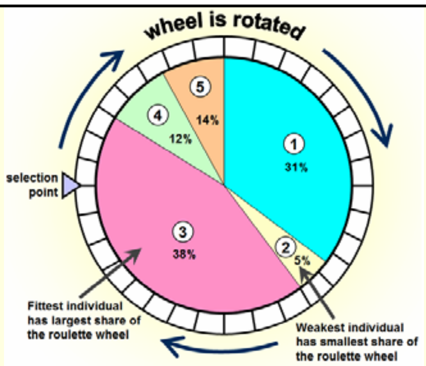
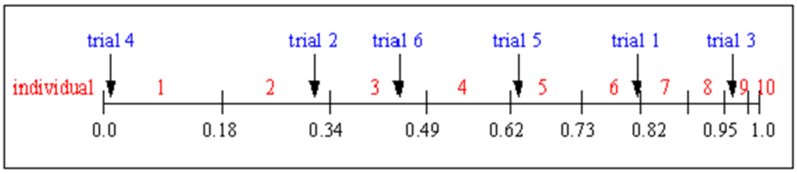
GAs Overview cont.



Example

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



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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***

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Implementation - Cadastral Analogy
cont.

A Successive Generation:

- *Parent selection - Tournament method*
- *Crossover*
- *Process repetition*
- *Averaging*
- *Mutation*

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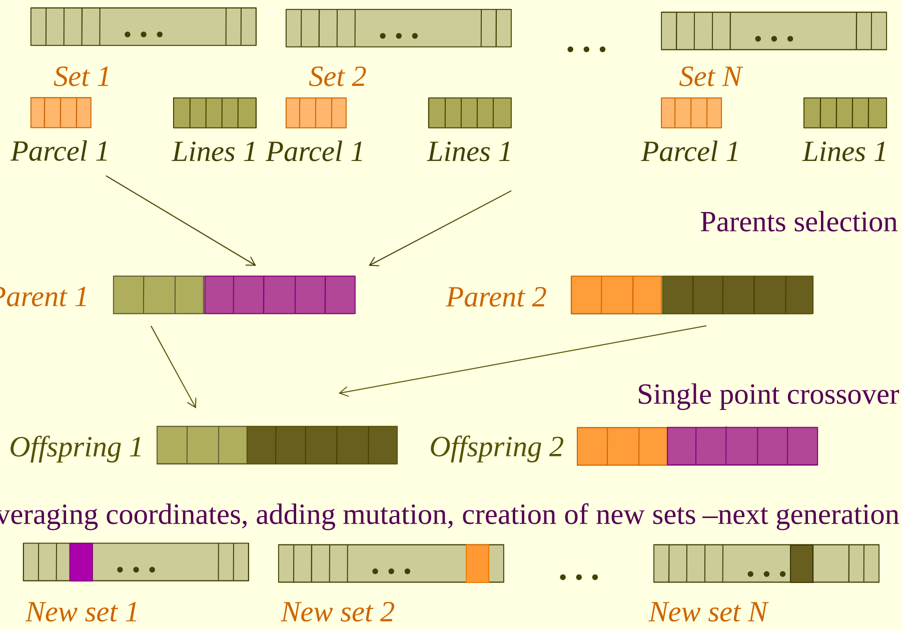
The proposed algorithm - graphical illustration



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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*

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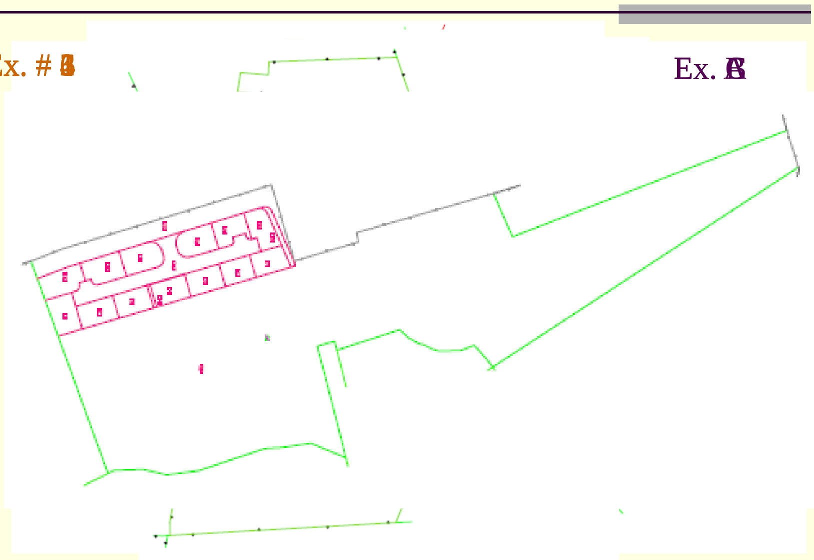
Case Studies cont. - Figures

Ex. #

Ex.



Case Studies cont.

Parameters

No. of Constraints	*Ex. #1*	*Ex. #2*	*Ex. #3*	*Ex. #4*	*Ex. #5*	*Ex. #6*
Parcels	17	18	20	25	26	111
Straight Lines	8	2	7	5	3	9
Pairs of Lines	3	1	11	1	5	2

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Case Studies cont.

Case Studies' Fitness Values

Fitness Values	Example A			Example B			Example C		
	LS	Init.	GAs	LS	Init.	GAs	LS	Init.	GAs
Total	88	67	**95**	44	44	**77**	90	67	**94**
Parcels	84	66	**94**	31	34	**72**	89	70	**94**
Straight Lines	93	65	**100**	98	99	**99**	95	46	**100**
Pairs of Lines	94	69	**94**	90	36	**100**	98	31	**100**

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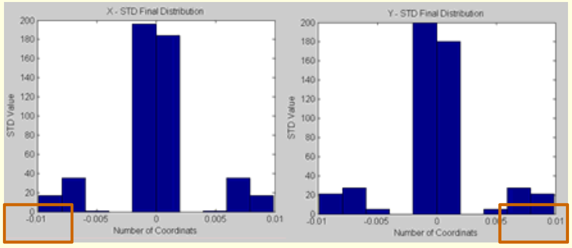
Case Studies cont. – Results Analyses

Parameters [m]	Example A		Example B		Example C	
	Initial	Final	Initial	Final	Initial	Final
$Mean_{\sigma_X}$	0.078	**0.002**	0.122	**0.002**	0.177	**0.003**
$Mean_{\sigma_Y}$	0.076	**0.002**	0.122	**0.002**	0.177	**0.003**
Max_{σ_X}	0.288	**0.010**	0.305	**0.009**	0.300	**0.014**
Max_{σ_Y}	0.281	**0.010**	0.286	**0.008**	0.315	**0.008**
$Max_{\Delta X}$	0.921	**0.038**	0.892	**0.035**	0.936	**0.041**
$Max_{\Delta Y}$	0.941	**0.043**	0.795	**0.042**	1.075	**0.046**
$Min_{\Delta X}$	-0.863	**-0.054**	-0.803	**-0.036**	-1.042	**-0.045**
$Min_{\Delta Y}$	-0.837	**-0.049**	-0.874	**-0.029**	-1.123	**-0.044**

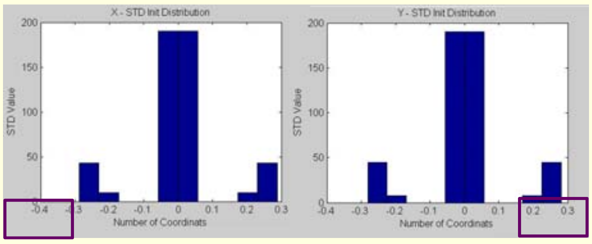
Case Studies cont. – Results Analyses

Coordinates’ Distributions Ex. A



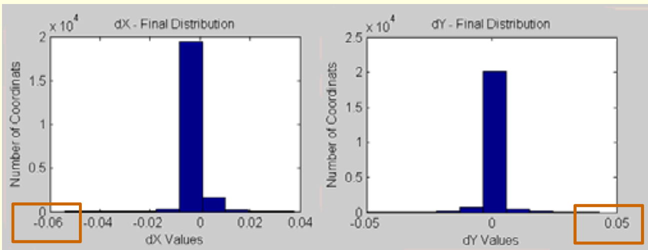
Final Coordinates’ Distribution

Initial Coordinates’ Distribution



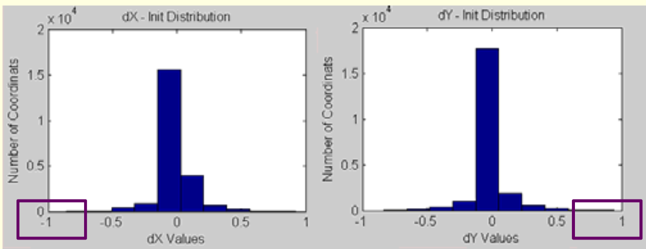
Case Studies cont. – Results Analyses

Coordinates’ Differences Distributions Ex. A



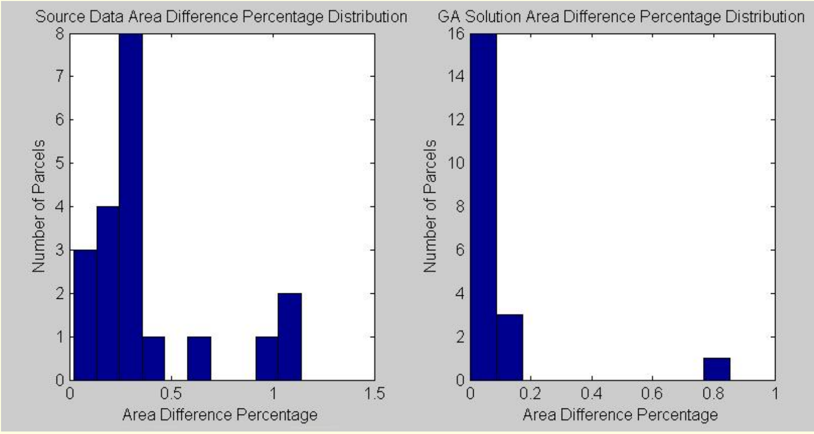
Final Coordinates’ Differences Distribution

Initial Coordinates’ Differences Distribution



Case Studies cont. – Results Analyses

- Area Difference Distribution - Ex. A



Source Data GAs' Solution

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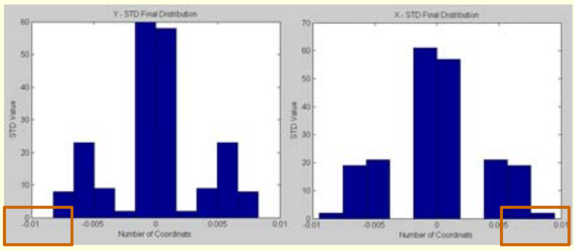
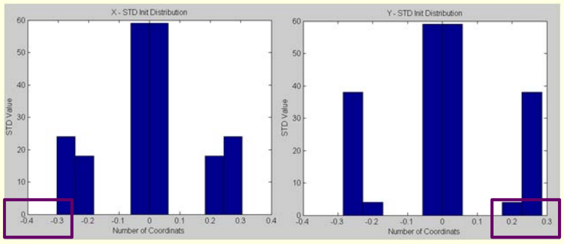
Case Studies cont. – Results Analyses

- Coordinates' Distributions Ex. B



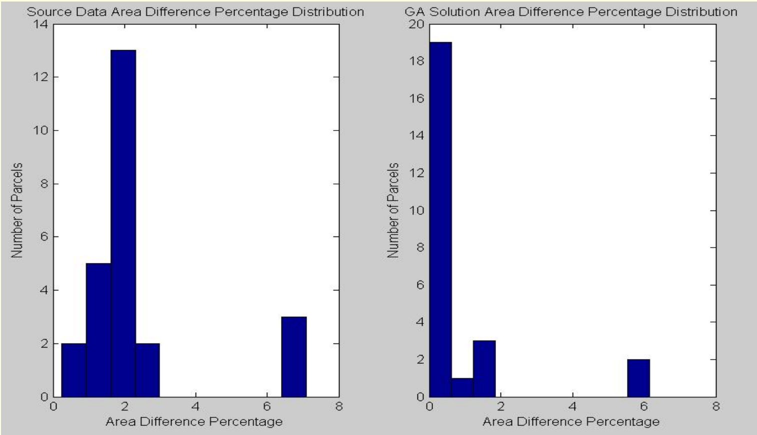
Final Coordinates' Distribution

Initial Coordinates' Distribution



Case Studies cont. – Results Analyses

- Area Difference Distribution - Ex. B



Source Data GAs' Solution

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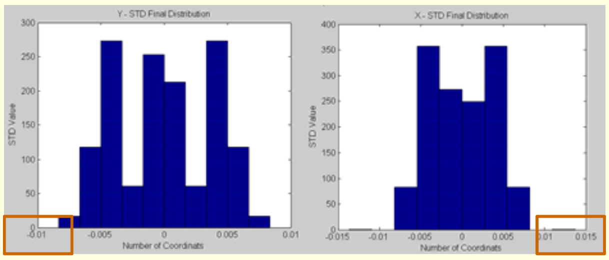
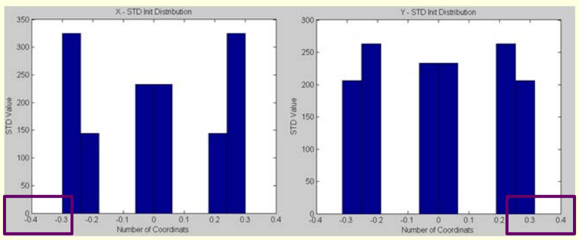
Case Studies cont. – Results Analyses

- Coordinates' Distributions Ex. C



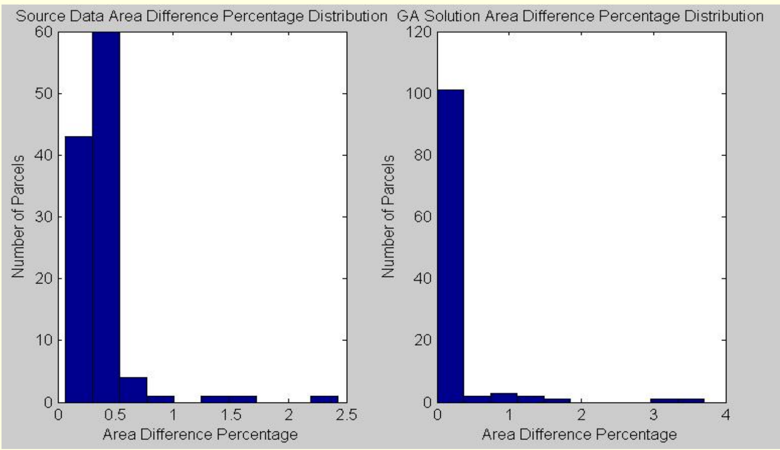
Final Coordinates' Distribution

Initial Coordinates' Distribution



Case Studies cont. – Results Analyses

- Area Difference Distribution - Ex. C



Source Data GAs' Solution

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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

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Summary & Future Work cont.

- The method provides very promising results
- ***Future Objectives***:
  - *Dealing with more complex situations*
  - *Integrating additional conditions*
  - *Working with adjacent blocks*

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