Parallel Niching Genetic Algorithms

A Crowding Perspective

Project: Minor Thesis
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Problem and Questions

☐ Type of Problem Domains
- "*Difficult*" search problem domains
- Not-feasible to exhaustively search
- Desire multiple approximate "*Good Enough*" solutions

☐ Questions Addressed
- What is a "*Niching Genetic Algorithm*" and "*Crowding*"?
- Is there a Common Template & Framework for Crowding Algorithms?
- What are observed behaviours of my proposed Simple Crowding algorithm?
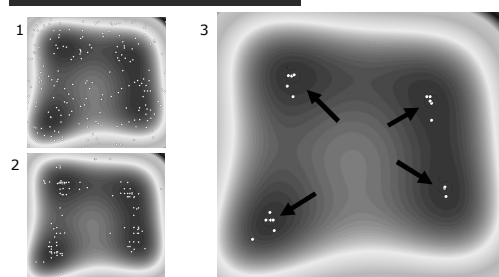

Standard Genetic Algorithm
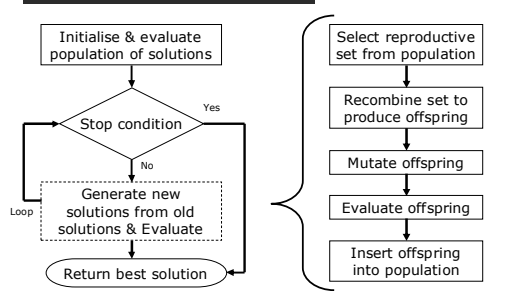
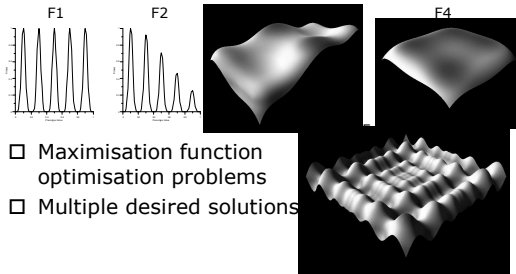
Example – **Without** Niching
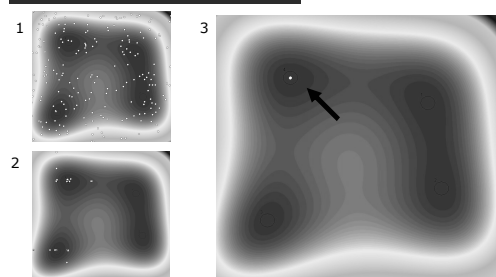
Parallel Niching Genetic Algorithm (Crowding)

☐ **Niching** – groups of similar samples at areas of interest in the search space
- Locate and maintain multiple solutions

☐ **Parallel** – multiple niches in one population

☐ **Crowding** - a way of niching

☐ "*Localised competition for limited resources*"
- Localised – Similarity between samples
- Limited Resource – Places in population
- Competition – Solution Quality/Usefulness
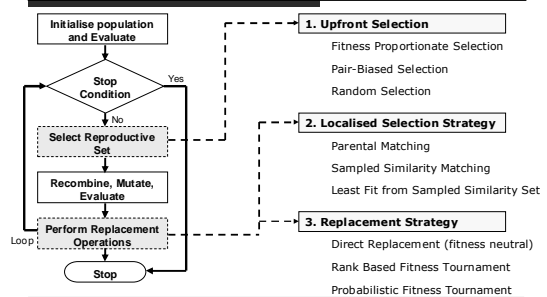
☐ "*Restrictive Replacement Algorithm*"

Example – **With** Niching

Multimodal Function Optimisation - Test Problems

F1   F2   F4

- Maximisation function optimisation problems
- Multiple desired solutions

Generalised Crowding Model

| Initialise population and Evaluate |
| Stop Condition |
| Select Reproductive Set |
| Recombine, Mutate, Evaluate |
| Perform Replacement Operations |
| Stop |

1. Upfront Selection
Fitness Proportionate Selection
Pair-Biased Selection
Random Selection

2. Localised Selection Strategy
Parental Matching
Sampled Similarity Matching
Least Fit from Sampled Similarity Set

3. Replacement Strategy
Direct Replacement (fitness neutral)
Rank Based Fitness Tournament
Probabilistic Fitness Tournament

What value does the model add?

- Template for existing crowding algorithms
  - Discrete functional units or algorithm operators
  - Various biasing and approximation techniques
- Framework for analysis and development of crowding algorithms
  - Test and evaluate logical units independently
  - What is the behaviour of an archetype crowding algorithm?
- Refined crowding definition:
 - "*Localised Generational Competition*"

New Algorithm: Simple Crowding

- Embodiment of Crowding Principle
  - "*Localised Generational Competition*"
- A possible prototype of Crowding in Search
- Algorithm Features
  - Entire population participates, random pairing
  - Exact similarity matching
  - Rank based fitness competition
- No forced bias or similarity approximations
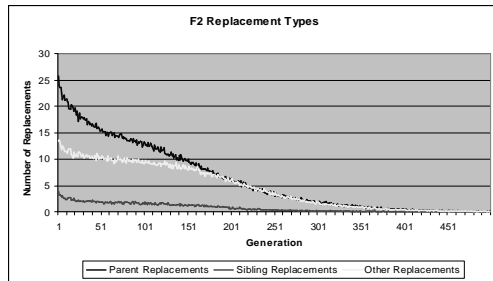- Analysis tool for crowding in search

Some Preliminary Observations

- Upfront Selection (Solution Pairing)
  - Natural bias (~80%) towards different-niche pairing
- Recombination (New Solutions)
  - Natural bias (98%) towards same-niche offspring
- Localised Selection (Similarity Matching)
  - Interesting transitional matching behaviour
- Replacement Strategy (Actual Replacements)
  - Trend towards equal probability of the replacements of parents or some other solutions

Interesting Matching Behaviour

F2 Total Similarty Match Types

Parent Matches — Sibling Matches — Other Matches
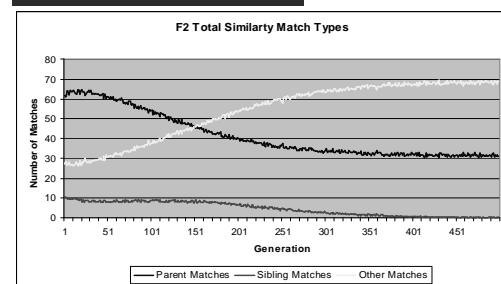
## Interesting Replacement Behaviour

F2 Replacement Types

Augmentations to Simple Crowding

☐ Upfront Selection
  ■ What are the effects of same-niche and different-niche selection of parents (pairing)?
☐ Localised Selection Strategy
  ■ What are the effects of small and large samples sizes to select from?
☐ Replacement Strategy
 ■ What are the effects of different replacement strategies?

Some Preliminary Observations

☐ Same-niche and different-niche pairing
  ■ Faster to reach a state of minimal change with bias towards different-niche pairings
☐ Small and large samples sizes
  ■ Smaller the sample, the less stable the subpopulations
☐ Different replacement strategies?
  ■ Exact localised replacement can maintain some stability of subpopulation size alone

Localised Selection: Effect of Selection from Small Sample Size

F1 Population Distribution
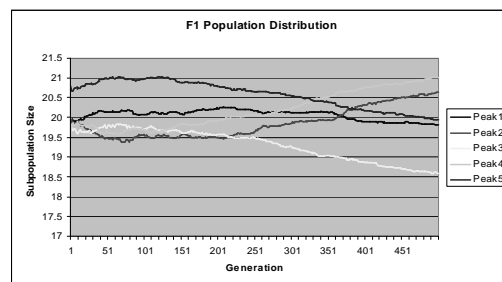
Localised Selection: Effect of Selection from Large Sample Size

F1 Population Distribution
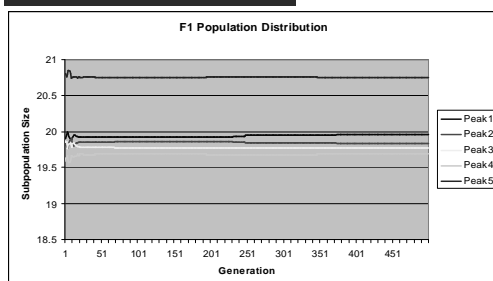
Summary of Main Findings

☐ Upfront Selection
  ■ Bias towards different-niche pairings gives similar results as same-niche pairings only sooner
☐ Similarity Matching
  ■ Interesting matching behaviour exhibited – not just matching & replacing parents
  ■ Identified Trade-off: Selected sample-size and the effects on niche stability
☐ Replacements
  ■ Shows trend towards equal chance of parent and non-parent replacements

Future Research

- Analytical modelling of the simple crowding algorithm
  - Attempt to explain matching and replacement behaviour
  - Further analyse the simple crowding algorithm
- Use framework and analysis measure to further develop a crowding based niching genetic algorithm
  - Devise an algorithm to address the needs of practical application
- Apply crowding principle elsewhere
  - Shown to be a Simple & Flexible concept
  - May be useful in other types of search algorithms
  - May be useful for other purposes such as data reduction

Acknowledgements

- My Advisor Professor Tim Hendtlass
  - Useful feedback providing grounding and clarity
- People at the CISCP
  - Meaningful discussion and airing of ideas

Questions

- Questions?