Anisotropic Selection in Cellular Genetic Algorithms

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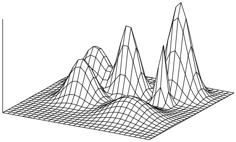
Exploration / exploitation tradeoff

One of the fondamental problem in EA



- Too much exploitation : population get stuck in local optima
- Too much exploration : random walk on fitness landscape

$\longrightarrow$ exploration / exploitation tradeoff

Selective Pressure in EA

the ability of best solutions to conquer the whole population

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Selective Pressure
$\Longrightarrow$ Population Diversity
$\Longrightarrow$ Exploration / Exploitation tradeoff

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$$\begin{array}{ll} & \text{Selective Pressure} \\ \Longrightarrow & \text{Population Diversity} \\ \Longrightarrow & \text{Exploration / Exploitation tradeoff} \end{array}$$

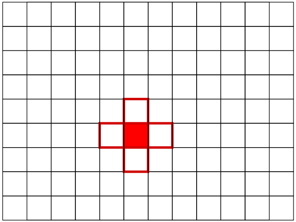
Some methods which try to tune selective pressure :

- Island models
- Sharing methods
- Cellular Genetic Algorithm
- ...

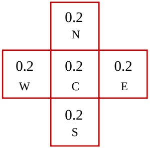
Cellular Genetic Algorithms

spatial structured population

One solution in each cell



- Neighborhood : Von Neumann, ...



Cellular Genetic Algorithms

spatial structured population

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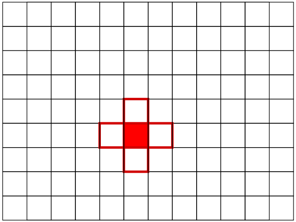

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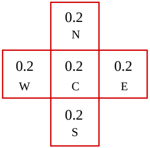

- Genetic operators are local:
  Selection of parents within the neighborhood (tournament selection,...)
- After selection, crossover, mutation:
  Replacement of the solution in C if better

Cellular Genetic Algorithms

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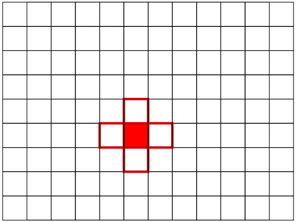

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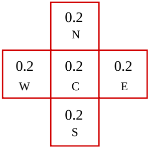

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- After selection, crossover, mutation:
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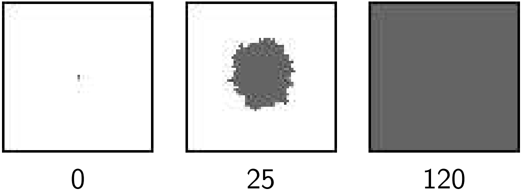
- Overlapping neighborhoods : implicit mechanism for migration → control selective pressure

Mesure of selective pressure

The Takeover Time [Goldberg 90] is the time it takes for the single best solution to conquer the whole population when the only active operator is selection.



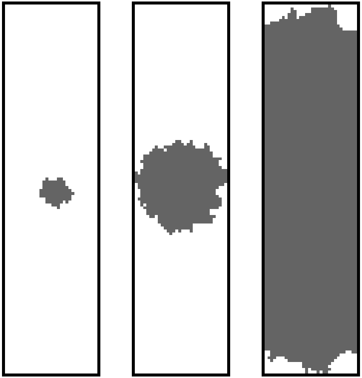
- Long takeover time : low selective pressure
- Short takeover time : high selective pressure

Grid Shape and takeover time

Pop. size $= 2^{12}$	Avg Takeover Time
64×64	83.4
32×128	117.8
16×256	225.0
8×512	449.7
4×1024	937.1
2×2048	2101.2

- Square grid : takeover time is short
  High selective pressure
- Narrow grid : takeover time is long
  Low selective pressure

Spreading of best solution



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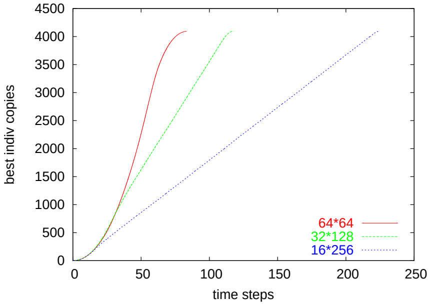

- 3 times in spreading[Giacobini 05]: quadratic, linear, quadratic

Tune selective pressure by grid shape

- Not many different grid shapes :
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During optimisation process, we would like selective pressure

Low (or high) at the beginning

High (or low) at the end

$\longrightarrow$ Dynamic change of shape grid [Alba *et al* 05]

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But...

- Dynamic changes of the grid affect the neighborhood relations

Tune selective pressure by grid shape

- Dynamic changes of the grid affect the neighborhood relations

0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15

"rectangular" grid

$\longrightarrow$

0	1	2	3
4	5	6	7
8	9	10	11
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"Square" grid

Anisotropic Selection

Modify the probability to participate to the tournament according to the direction

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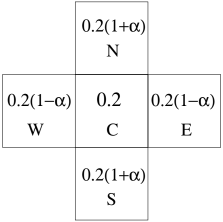

Probability to participate to the tournament :

- cell center : $p_c = 0.2$
- north or south cell : $p_{ns} = \frac{(1-p_c)}{2}(1+\alpha)$
- east or west cell : $p_{ew} = \frac{(1-p_c)}{2}(1-\alpha)$

Anisotropic Selection

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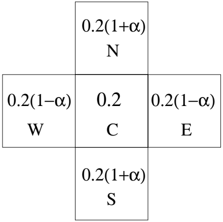

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α tunes the anisotropic degree of anisotropic selection

Anisotropic Selection : “Fuzzy” neighborhood

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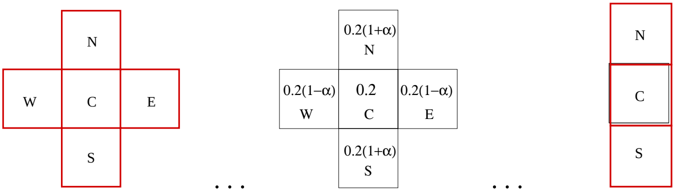
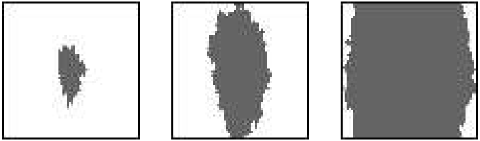
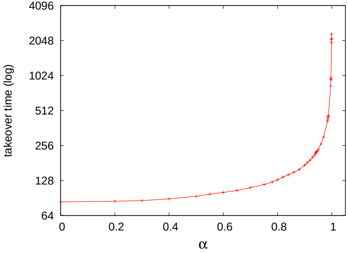
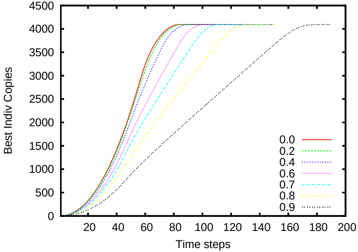


$\alpha = 0$	α	$\alpha = 1$
Von Neumann Neighborhood	“fuzzy” Neighborhood	line Neighborhood

Anisotropic Selection and Selective Pressure







Takeover Time
versus Anisotropic degree α

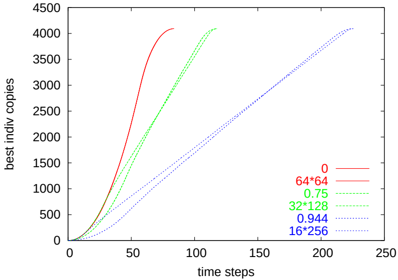
Growth curves

Comparaison of grid shape / anisotropic selection

Values of α and $\frac{l}{L}$ for the same takeover time.

$$\alpha \approx 1 - \frac{l}{L}$$

where l is the larger and L the longer



Growth curves

Quadratic Assignment Problem (QAP)

Problem of assigning a set of N facilities to a set of N locations with given distances between the locations d_{ij} and given flows between the facilities f_{ij}

$$\Phi(p) = \sum_{i=1}^{N} \sum_{j=1}^{N} d_{p(i)p(j)} f_{ij}$$

where $p(i)$ is the location of facility i

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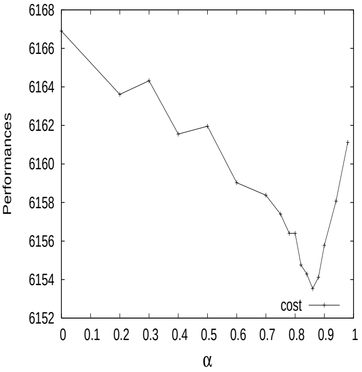
Is there an optimal tradeoff between exploration and exploitation for QAP ?

Set Up

Simple cellular GA with anisotropic selection :

- Population of $400 = 20 \times 20$ solutions
- Crossover and mutation preserving permutations
- Crossover rate is 1
- Mutation rate is $\frac{1}{N}$, N size of a solution
- Each run stops after 1500 generations

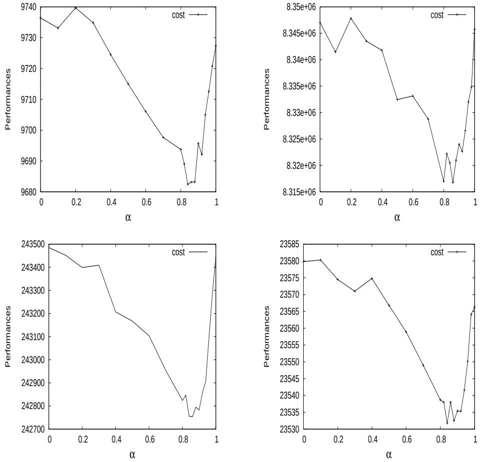
Optimal exploration / exploitation tradeoff



Nug30 (from QAPlib)

- Average performance over 500 runs
- Optimal value for $\alpha = 0.86$

Optimal exploration / exploitation tradeoff



left to right and top to bottom: ste36a, ste36c, tho40, sko49

Generational Snapshots

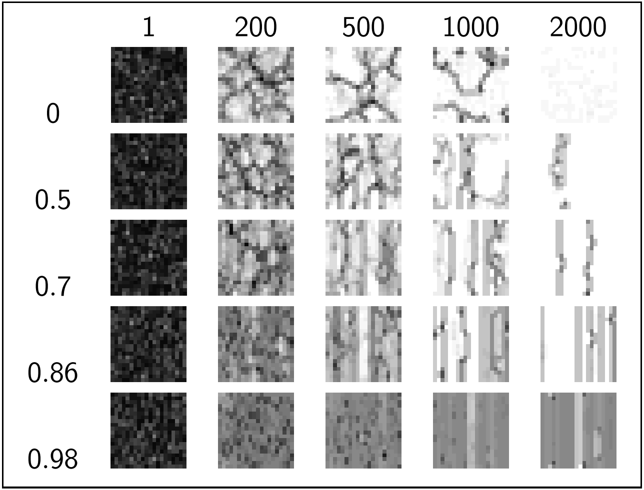
Diversity measure :

$$D(c_{i,j}) = d(c_{i,j}; c_{i+1,j}) + d(c_{i,j}; c_{i-1,j}) + d(c_{i,j}; c_{i,j+1}) + d(c_{i,j}; c_{i,j-1})$$

where d is the distance between two permutations

- Black : D is high,
  $\longrightarrow$ the local diversity is high
- White : D is low,
  $\longrightarrow$ the local diversity is low

Generational Snapshots



Conclusion and Future Works

We have proposed:

- New model of selection in cellular GA
- Control the selective pressure with a continous parameter
- Same selective pressure (takeover time) as toroidal grid
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Future works :

- Study the diversity (done in ACRI06)
- Give the equation of growth curve for Anisotropic Selection
- Look for an optimal value of anisotropic degree on other problems
- Auto-adaptation: Local behaviour of α