Universidad de Granada

Diversidad en AG

Manuel Lozano

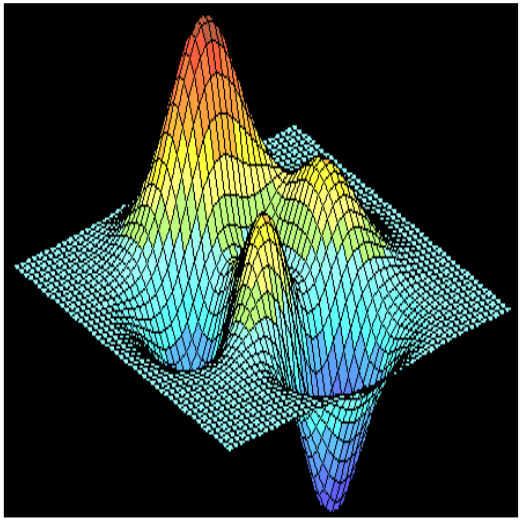
Email: lozano@decsai.ugr.es

Técnicas de Soft Computing
para
Aprendizaje y Optimización

DECSAI

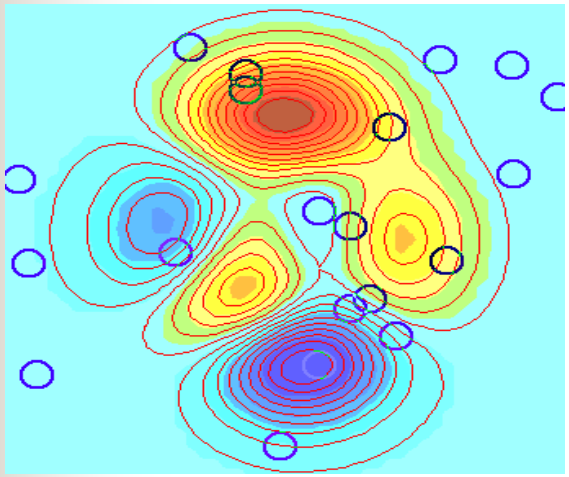
Departamento de Ciencias de la Computación e Inteligencia Artificial

Diversity versus convergence

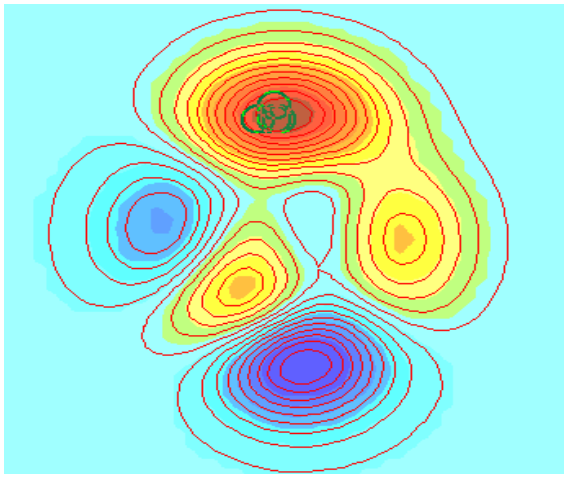


Diversity

Convergence



Conflict



Diversity versus convergence

Exploration and Exploitation in Evolutionary Algorithms: A Survey

MATEJ ČREPINŠEK, University of Maribor
SHIH-HSI LIU, California State University, Fresno
MARJAN MERNIK, University of Maribor

"Exploration and exploitation are the two cornerstones of problem solving by search." For more than a decade, Eiben and Schippers' advocacy for balancing between these two antagonistic cornerstones still greatly influences the research directions of evolutionary algorithms (EAs) [1998]. This article revisits nearly 100 existing works and surveys how such works have answered the advocacy. The article introduces a fresh treatment that classifies and discusses existing work within three rational aspects: (1) what and how EA components contribute to exploration and exploitation; (2) when and how exploration and exploitation are controlled; and (3) how balance between exploration and exploitation is achieved. With a more comprehensive and systematic understanding of exploration and exploitation, more research in this direction may be motivated and refined.

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Diversity and convergence

- ***Mechanisms for Convergence***
  - ***Competition***
    - ✓ *Tournament Parent Selection*
    - ✓ *Replace-Worst Replacement Mechanism*
- ***Mechanisms for Diversity***
  - ***Producing Diversity***
    - ✓ *Incest Prohibition*
    - ✓ *HUX Crossover*
    - ✓ *Restart Operator*
  - ***Maintaining Diversity***
    - ✓ *Crowding Methods*
    - ✓ *Distributed GAs*
    - ✓ *Multiploid Representations*

Incest prohibition

- ***MAIN IDEA:*** *The application of the crossover to similar parents generates offspring that do not offer diversity*

- ***Incest prohibition (Eshelman et al., 1991)***
  - P_1 and P_2 are mated only if $D_H(P_1,P_2)$ is above a *threshold*
  - The threshold *decreases* as evolution proceeds

HUX crossover

- ***MAIN IDEA:*** *Diversity may be introduced by generating offspring very different from their parents*

- ***HUX (Eshelman, 1991)***
  - HUX flips exactly *half of the different* bits between two parents
  - Children have always the *maximum Hamming distance* from their *two* parents

Restart operator

- ***MAIN IDEA:*** *To renew the population of GAs that have converged prematurely*

- ***Restart operator (Goldberg, 1989)***
  - *It restarts* the search with a *new population*
    - ✓ *New individuals* generated randomly
    - ✓ *Best individuals* from the previous population

Diversity and convergence

- ***Mechanisms for Convergence***
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    - ✓ *Tournament Parent Selection*
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- ***Mechanisms for Diversity***
  - ***Producing Diversity***
    - ✓ *Incest Prohibition*
    - ✓ *HUX Crossover*
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  - ***Maintaining Diversity***
    - ✓ *Crowding Methods*
    - ✓ *Distributed GAs*
    - ✓ *Multiploid Representations*

Crowding methods

- ***MAIN IDEA:*** *Diversity may be sustained by producing little changes with the introduction of new individuals*

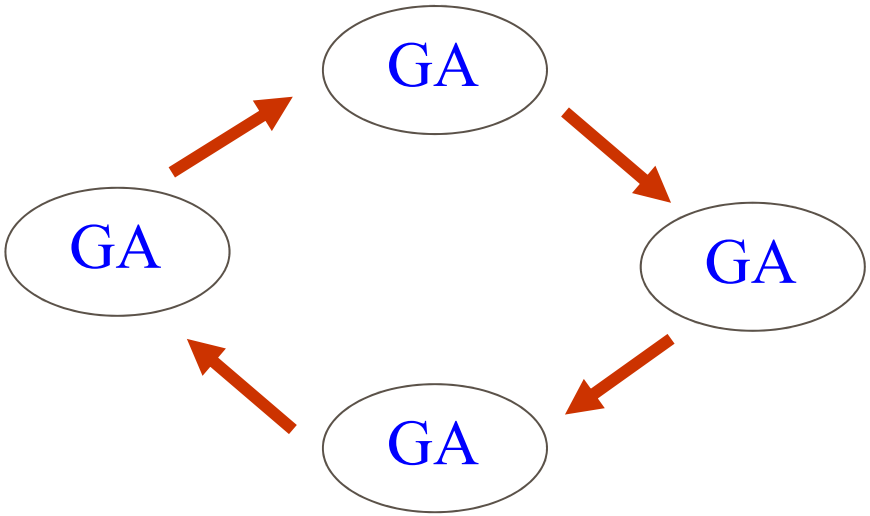
- ***Crowding (De Jong, 1975)***

  - ✓ New individuals *replace* individuals that are *similar* to themselves

  - ✓ ***Restricted tournament selection:*** To replace the closest individual *R* to the one being inserted in the population, *I*, from a set of n_T randomly selected ones, if *I* is better than *R*.

Distributed GAs

- ***MAIN IDEA:*** *Diversity may be preserved by isolating individuals in different subpopulations (spatial separation)*
- ***Distributed GAs (Tanese, 87)***
  - Several *subpopulations* are processed by *independent GAs*
  - A *migration operator* produces a chromosome *exchange* between them

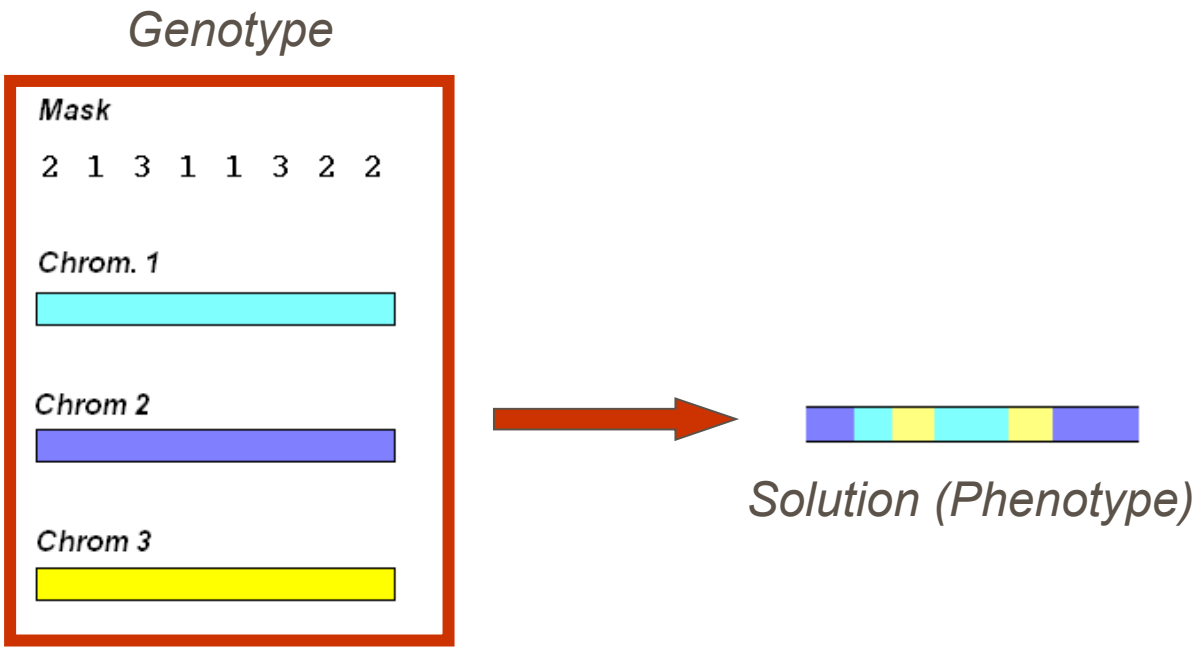


Multiploid chromosomes

- ***MAIN IDEA:*** *In nature, many organisms have multiploid genotypes*
  - *Multiple chromosomes (genotype)*
  - *Mechanism for determining the phenotype*
    - ✓ *It determines which of the chromosomes has the dominant gene at each locus*
- *The use of multiploid genotypes <u>enhances diversity</u>*
  - *Unused genes remain in a multiploid genotype until they may later become useful (“latent diversity”)*

Multiploid chromosomes

- ***Multiploid chromosomes (Collingwood et al., 1996)***
  - A *solution* is represented by ***p*** chromosomes (***p***>1)
  - A *mask* is used for obtaining the corresponding solution



Diversity and convergence

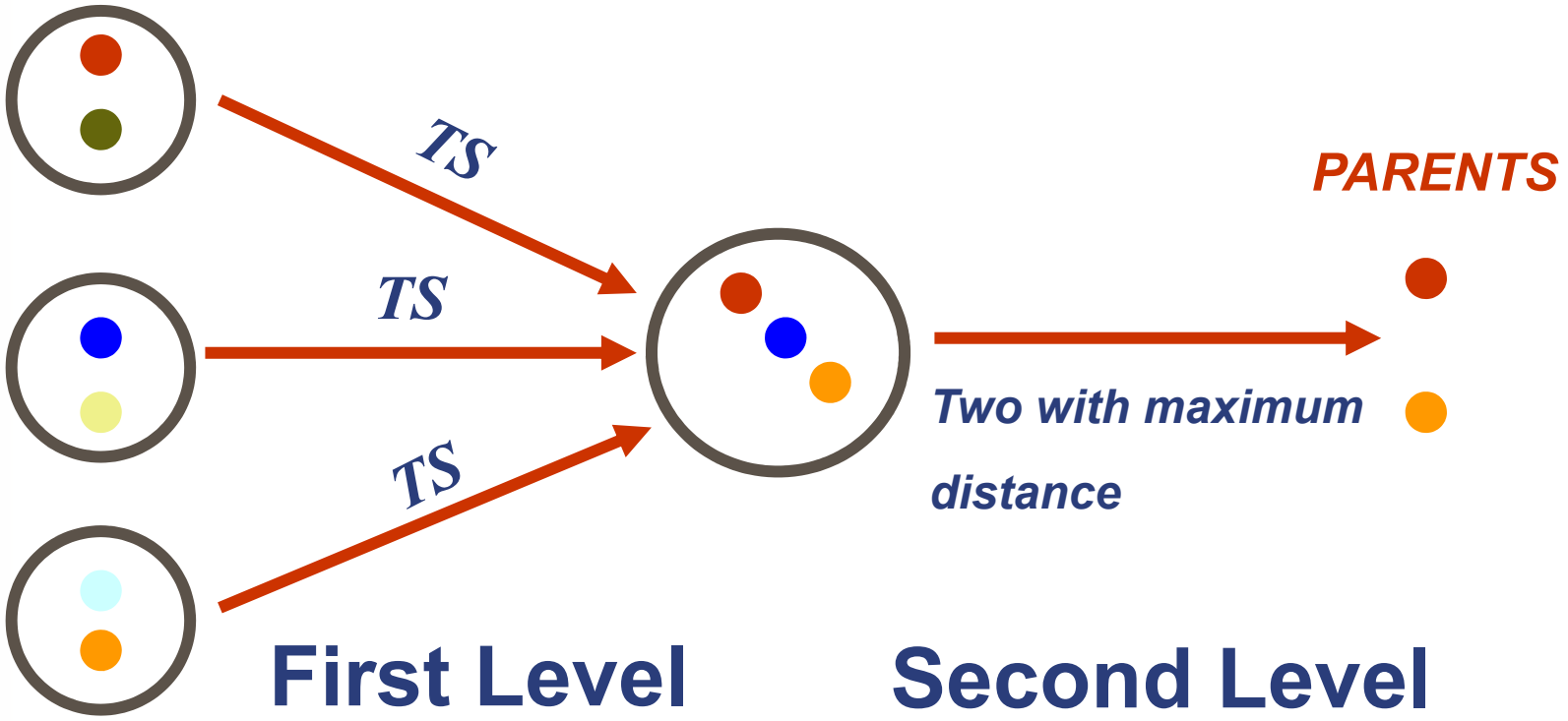
- ***Mechanisms to Combine Diversity and Convergence***

  - *Two-level Tournament Parent Selection*
  - *Evolutionary Algorithms*
    - ***CHC Algorithm***
    - ***Micro GAs***
    - ***Saw-tooth GA***
    - ***Gradual distributed GAs***

Two-level TS

- ***MAIN IDEA:*** *To select as parents the individuals that are both:*
  - ✓ *Fit, and*
  - ✓ *Diverse in relation to others (they provide diversity!)*

- ***Two-level TS (Brameier, 2002)***



Favouring fit and diverse chroms.

- Fitness sharing (Goldberg et al., 1987)
- Thermodynamical selection (Mori et al., 1995)
- Disruptive selection (Kuo et al., 1996)
- Diversity control oriented GA (Shimodaira, 1996)
- Multi-objective methods (De Jong et al., 2001)
- Lineage selection (Burke et al., 2003)
- Entropy-boltzmann selection (Lee, 2003)

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Replacement strategies to preserve useful diversity in steady-state genetic algorithms

Manuel Lozano [a,*], Francisco Herrera [a], José Ramón Cano [b]

[a] Department of Computer Science and Artificial Intelligence, University of Granada, 18071 Granada, Spain
[b] Department of Electronic Engineering, Computer Systems and Automatics, Escuela Superior de La Rábida, University of Huelva, 21819 Huelva, Spain

Diversity and convergence

- ***Mechanisms to Combine Diversity and Convergence***
  - *Two-level Tournament Parent Selection*
  - *Decreasing Mutation Probability*
  - *BLX-α Real-Parameter Crossover*
  - *Evolutionary Algorithms*
    - ✓ ***CHC Algorithm***
    - ✓ ***Saw-tooth GA***
    - ✓ ***Gradual distributed GAs***
    - ✓ ***Memetic algorithms***

CHC algorithm

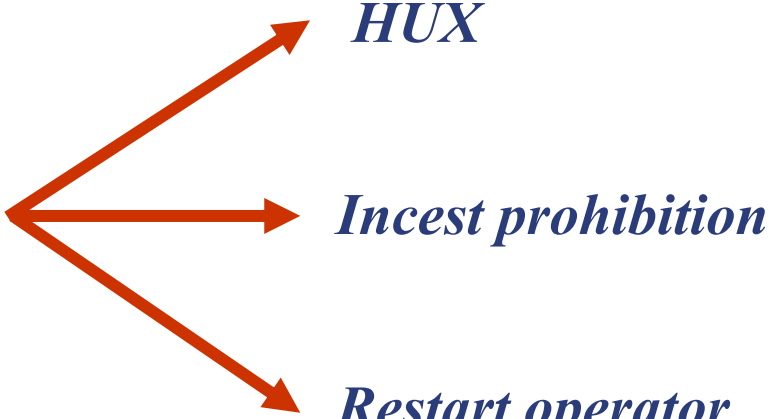
Idea:

High diversity

+

High selection pressure

(Eshelman et al., 1991)



HUX

Incest prohibition

Restart operator

Conservative selection strategy

(*It keeps the N best elements appearing so far*)

CHC algorithm

References

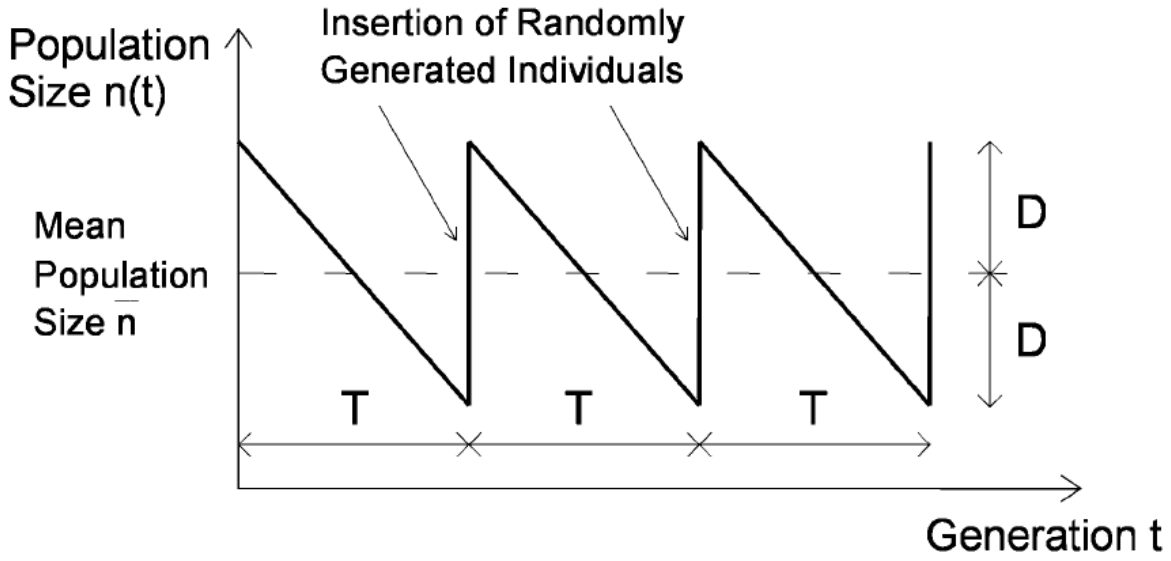
L.J. Eshelman (1991). The CHC adaptive search algorithm: how to have safe search when engaging in non-traditional genetic recombination. In: *Foundations of Genetic Algorithms 1*, Morgan Kaufmann, San Mateo, California, pp. 265-283.

L.J. Eshelman, K.E. Mathias, J.D. Schaffer (1997). Convergence controlled variation. In: *Foundations of Genetic Algorithms 4*, Morgan Kaufmann, San Mateo, California, pp 203-224.

Saw-Tooth GA

V.K. Koumousis and C.P. Katsaras. IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION, VOL. 10, NO. 1, FEBRUARY 2006

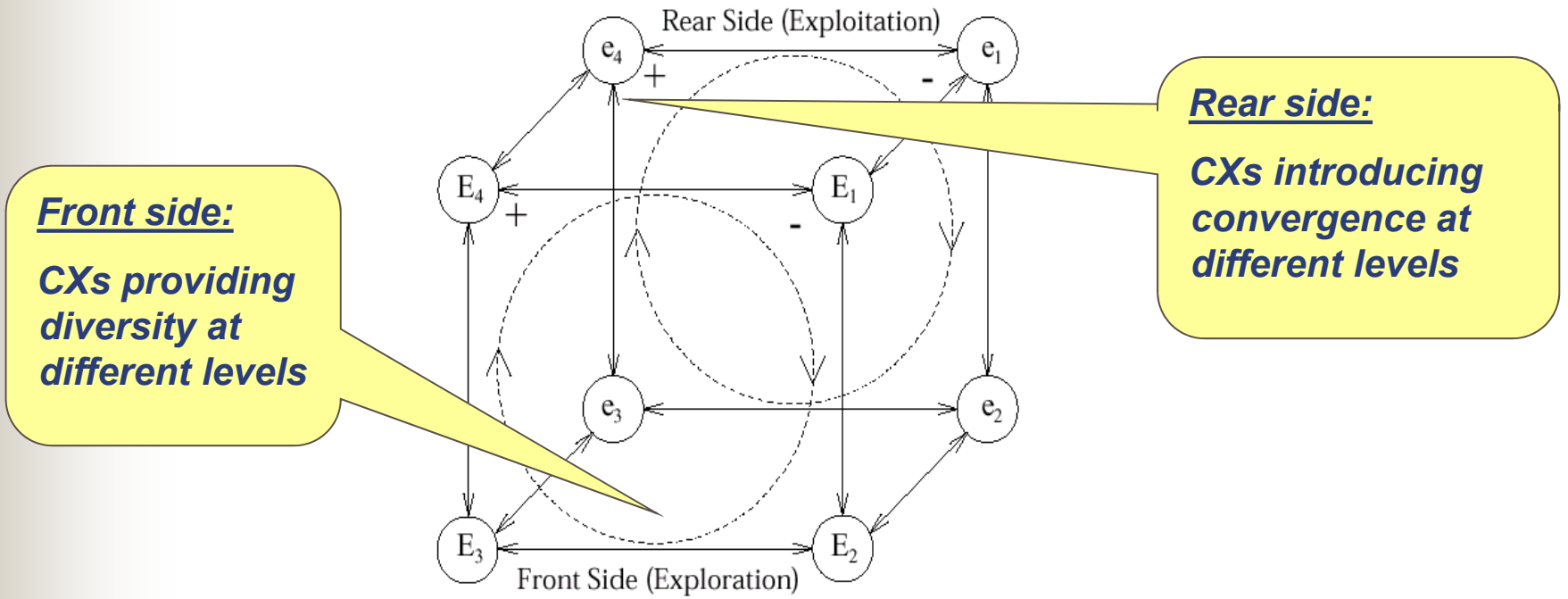
- It uses variable population size with periodic reinitialization
- In each period, the ***population size decreases*** linearly
- At the beginning of the next period ***randomly generated individuals*** are appended to the population



Gradual distributed GAs

- ***MAIN IDEA:*** *To provide different levels of diversity and convergence in a parallel way*

- ***Gradual DGAs (Herrera et al., 2000)***
  - ✓ DGAs that apply a *different crossover operator* to each subpopulation



Gradual distributed GAs

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