Universidad de Granada

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Algoritmos Evolutivos Híbridos

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Técnicas de Soft Computing para Aprendizaje y Optimización

DECSAI

Departamento de Ciencias de la Computación e Inteligencia Artificial

Metaheuristics

- *Simulated annealing*
- *Tabu search*
- *Evolutionary algorithms (EAs)*
- *Particle swarm optimization (PSO)*
- *Ant colony optimization (ACO)*
- *Estimation of distribution algorithms (EDAs)*
- *Scatter search*
- *Path relinking*
- *Greedy randomized adaptive search procedure (GRASP)*
- *Iterated local search (ILS)*
- *Guided local search*
- *Variable neighborhood search (VNS)*

Hybrid Metaheuristics

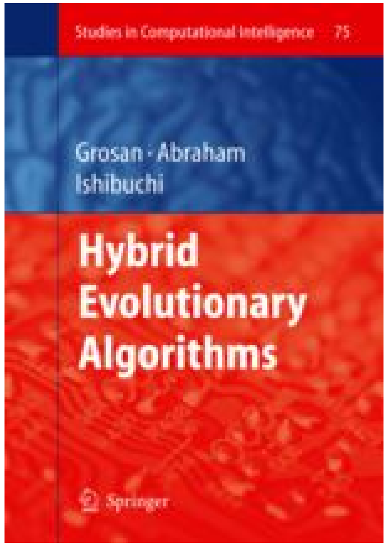
Search algorithms that do not purely follow the concepts of one single classical MH.

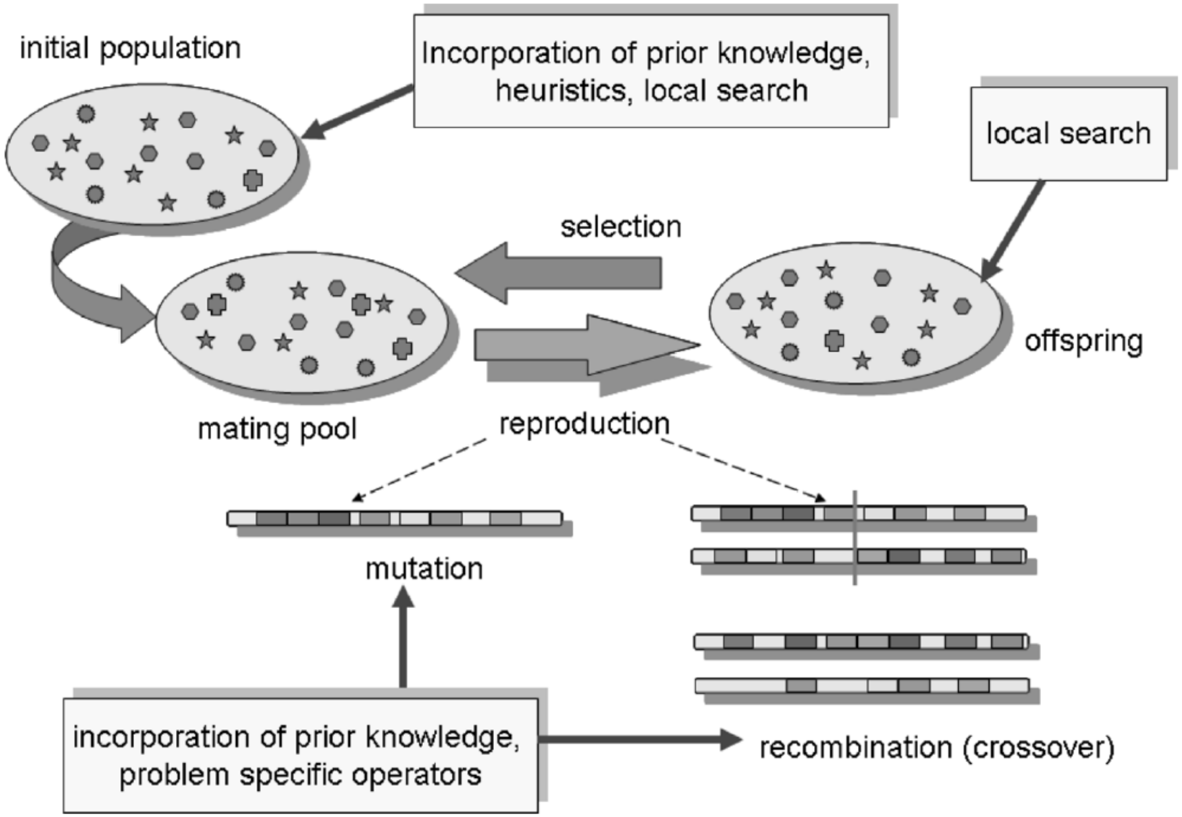
*They attempt to obtain the best from **a set of MHs** that perform together and complement each other to produce a profitable **synergy from their combination**.*

Talbi E-G. A taxonomy of hybrid metaheuristics. J. Heuristics 2002;8(5): 541–65.

C. Blum, J. Puchinger, G. Raidl and A. Roli. Hybrid metaheuristics in combinatorial optimization: a survey. Applied Soft Computing, 11(6):4135–4151, 2011.

Hybrid Evolutionary Algorithms

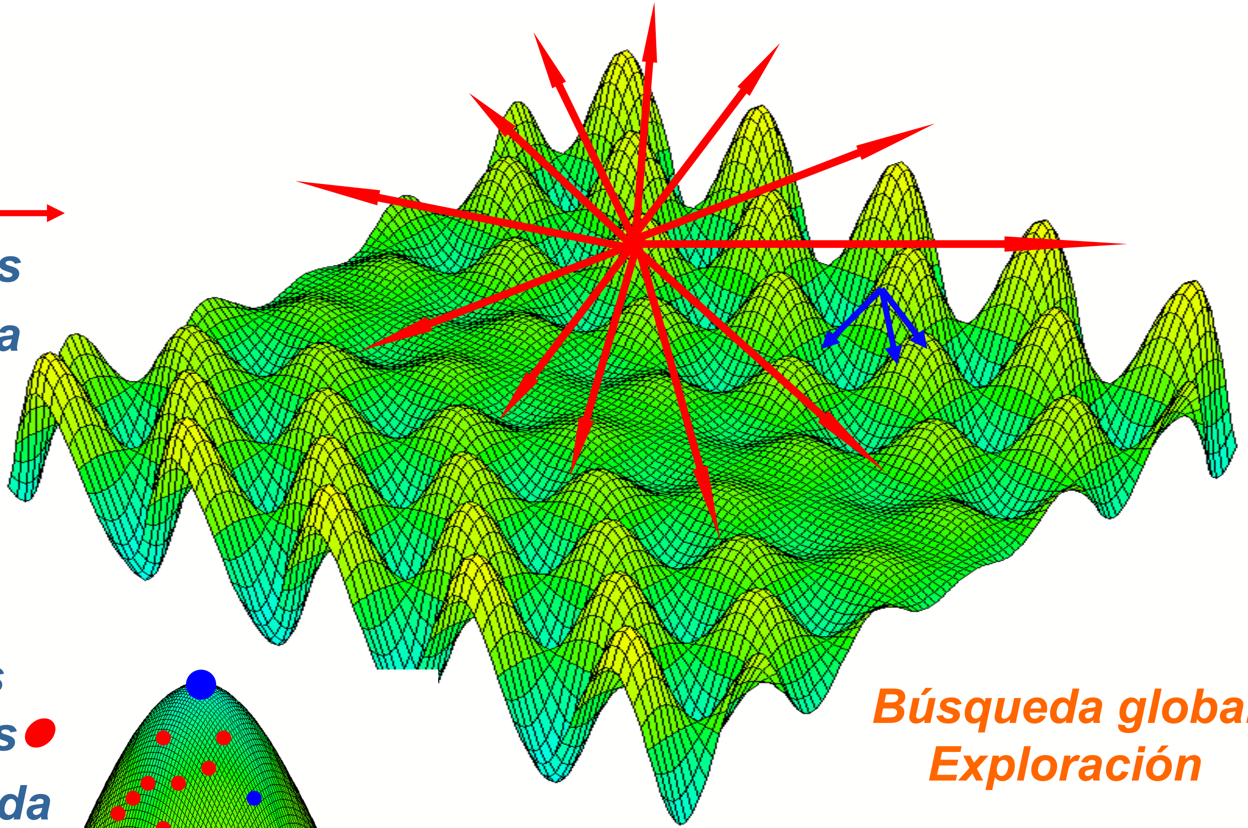




Grosan C, Abraham A. Hybrid Evolutionary Algorithms: Methodologies, Architectures, and Reviews. In: Grosan C, Abraham A, Ishibuchi H, editors. Hybrid evolutionary algorithms. Berlin, Heidelberg: Springer; 2007. p. 1–17.

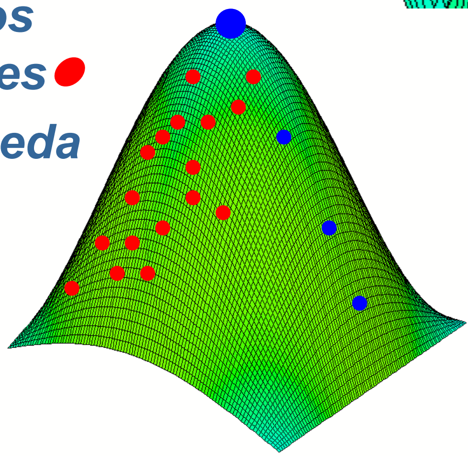
Algoritmos Meméticos

- *Algoritmos evolutivos son buenos exploradores*
- *Algoritmos de búsqueda local son malos exploradores*



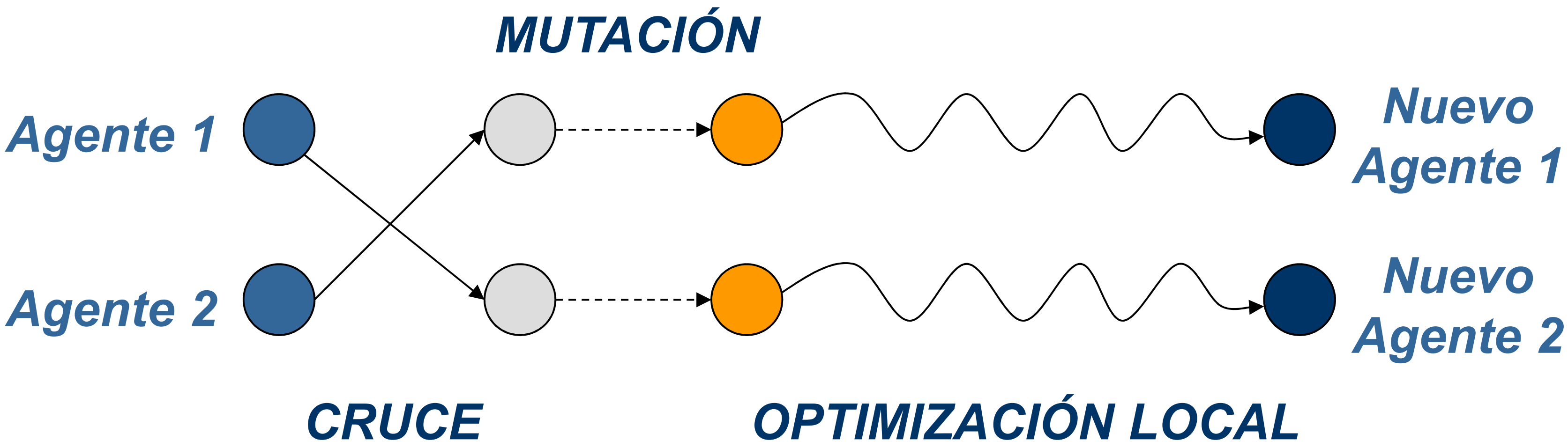
Búsqueda global
Exploración

- *Algoritmos evolutivos son malos explotadores*
- *Algoritmos de búsqueda local son buenos explotadores*



Búsqueda local
Explotación

Algoritmos Meméticos



Algoritmos Meméticos con Intensidad de BL Adaptable

D. Molina, M. Lozano, C. García-Martínez, F. Herrera, **Memetic Algorithms for Continuous Optimization Based on Local Search Chains**. *Evolutionary Computation*, 18(1), 2010, 27–63.

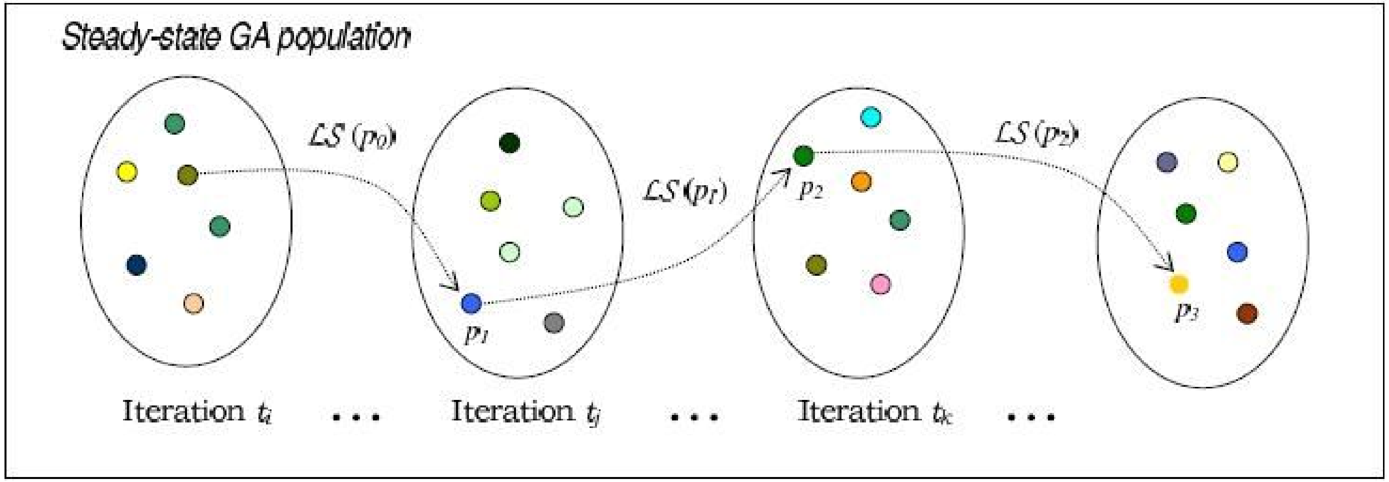


Figure 3: Example of LS chain. p_{i+1} is the final parameter value reached by the LS algorithm when it started with a value of p_i. p_0 is the default value for the strategy parameter

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Hybrid MHs based on EAs and Simulated Annealing

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IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION, VOL. 16, NO. 6, DECEMBER 2012 787

Hybrid Metaheuristics Based on Evolutionary Algorithms and Simulated Annealing: Taxonomy, Comparison, and Synergy Test

Francisco J. Rodriguez, Carlos García-Martínez, and Manuel Lozano

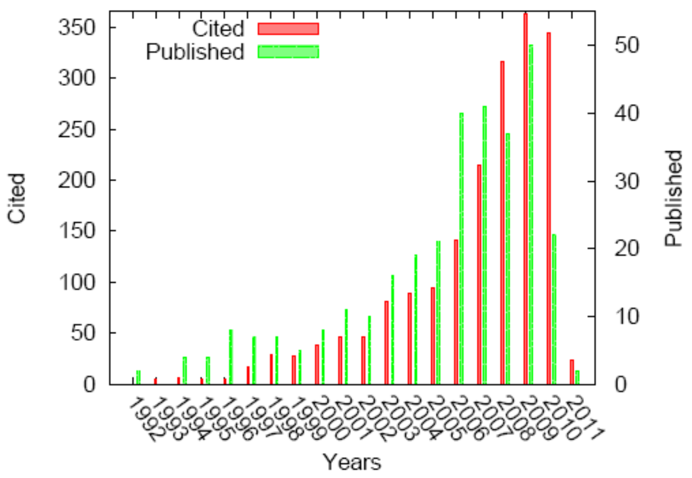


Fig. 1: Number of publications and citations per year for HMs-EA/SA (Web of Science)

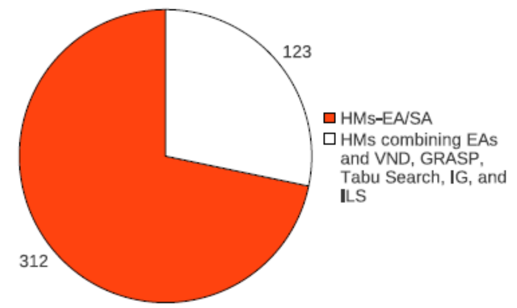


Fig. 2: Comparison between publications considering HMs-EA/SA and hybrid algorithms combining EAs and other metaheuristics (Web of Science)

Hybrid MHs based on EAs and Simulated Annealing. Taxonomía

TABLE I
TAXONOMY FOR HMS-EA/SA

General Categories		HM-EA/SA Categories	Instances
Collaborative	Teamwork	Multiple EAs and SAs	DCHCSA
		Multiple SAs	SSSA [23], CSA [35], ESA [36], GAMSA [37]
	Relay	EA then SA	HHSAGA [38], SAGA [39]
		SA then EA	GA-PSA
Integrative	TeamWork	MA with SA as local search	AGA [40], GASAHA [31], IGA-SA [41], GSAAL [42], GSAA [24]
		SA-based EA selection	HGA-BTS [43], GESA [44], HGA-BS[45]
		SA-based EA mutation and crossover	SAGACIA [46], ARSAGA [47], GSAAIA [48], HGA-SAM/R [49]
		SA-based EA replacement	PRSA [50], PGSA [25], GSA [51], NPOSA [52], MPGSAA [26], GSA-MLE [53]
	Relay	EA-based SA component	SALGeS [54] GAMSA [37]

Hybrid MHs based on EAs and Simulated Annealing

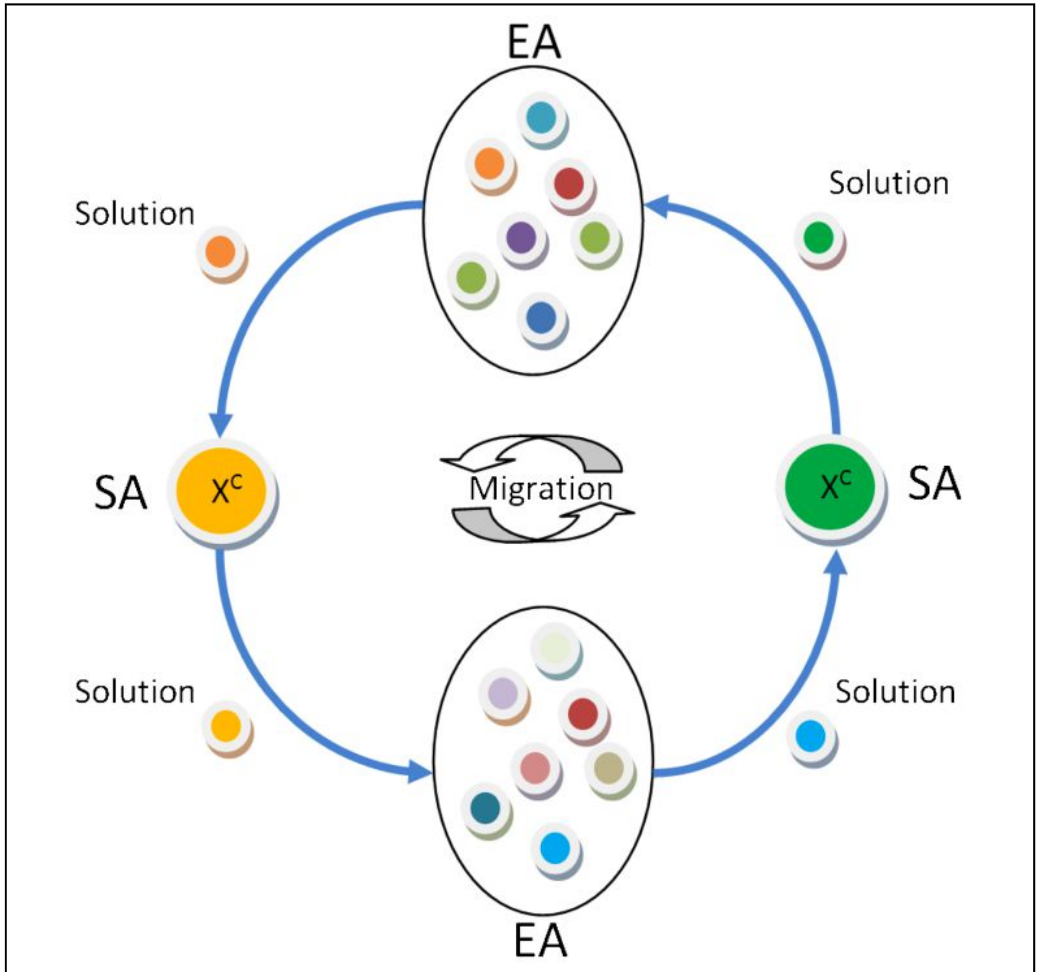


Fig. 3. Multiple EAs and SAs running in parallel.

Hybrid MHs based on EAs and Simulated Annealing

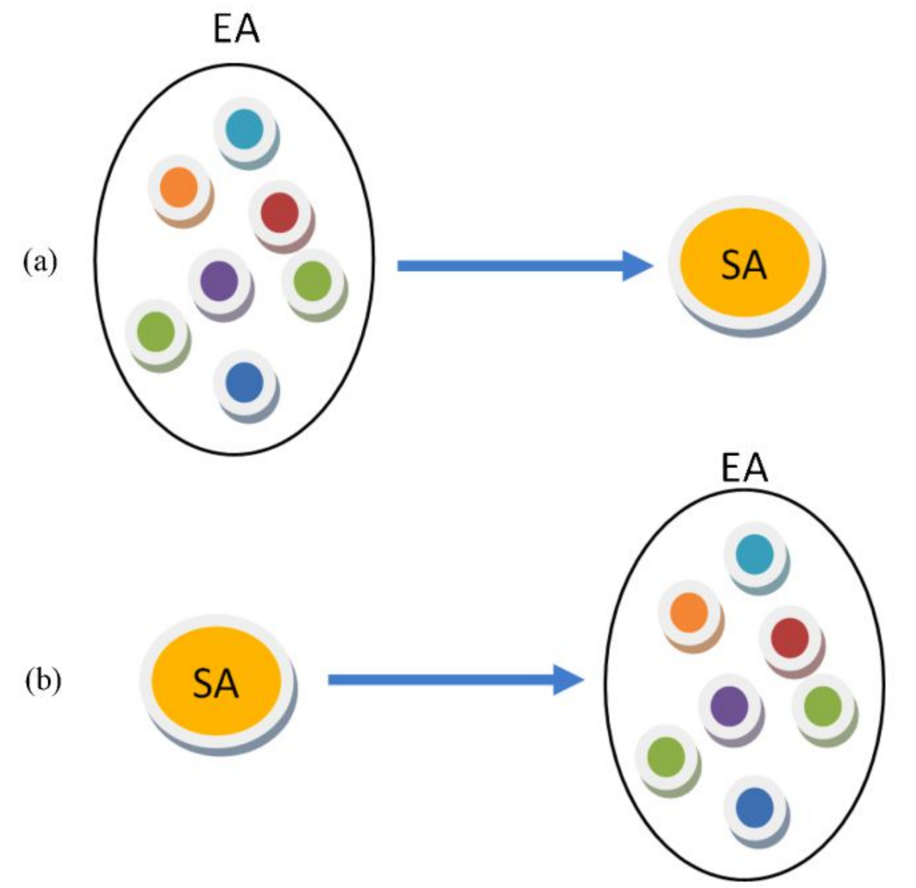


Fig. 5. EAs and SAs in a pipeline fashion. (a) EA then SA. (b) SA then EA.

Hybrid MHs based on EAs and Simulated Annealing

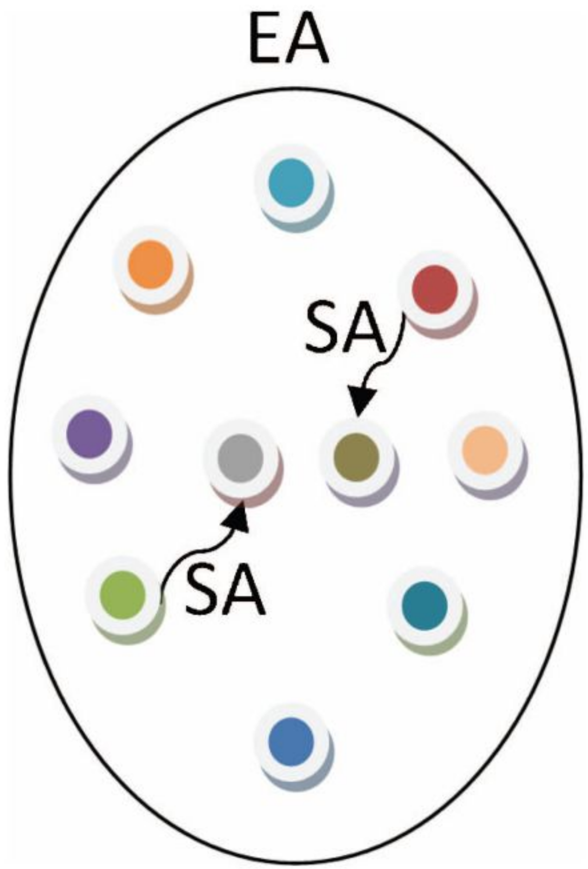


Fig. 6. MA with SA as local search procedure.

Hybrid MHs based on EAs and Simulated Annealing

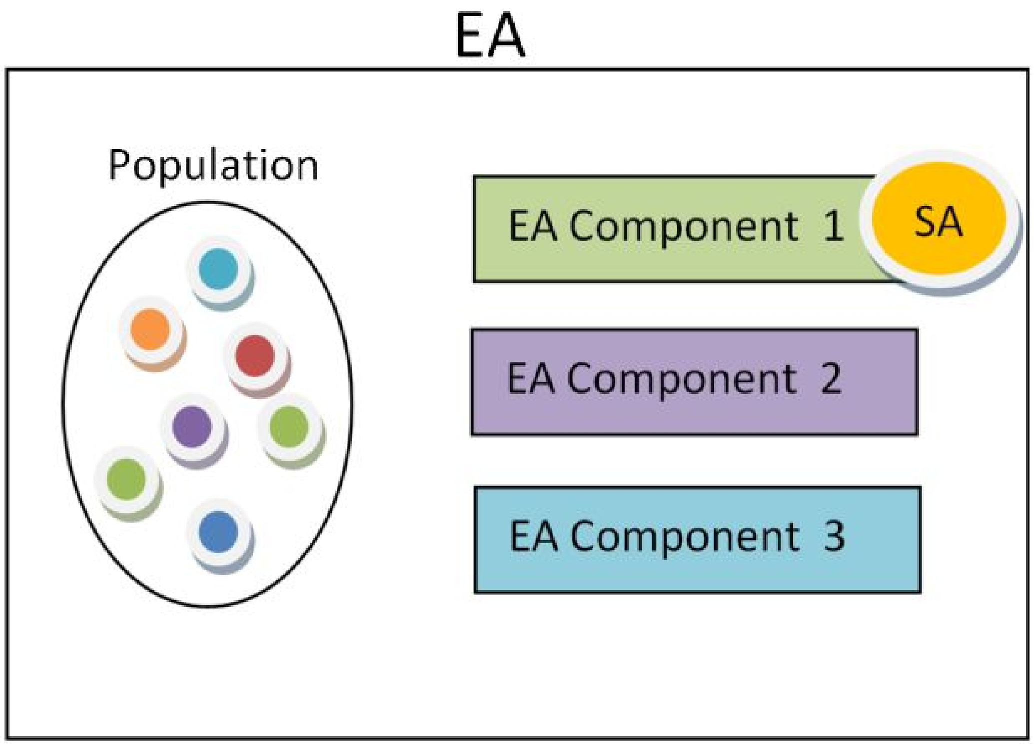
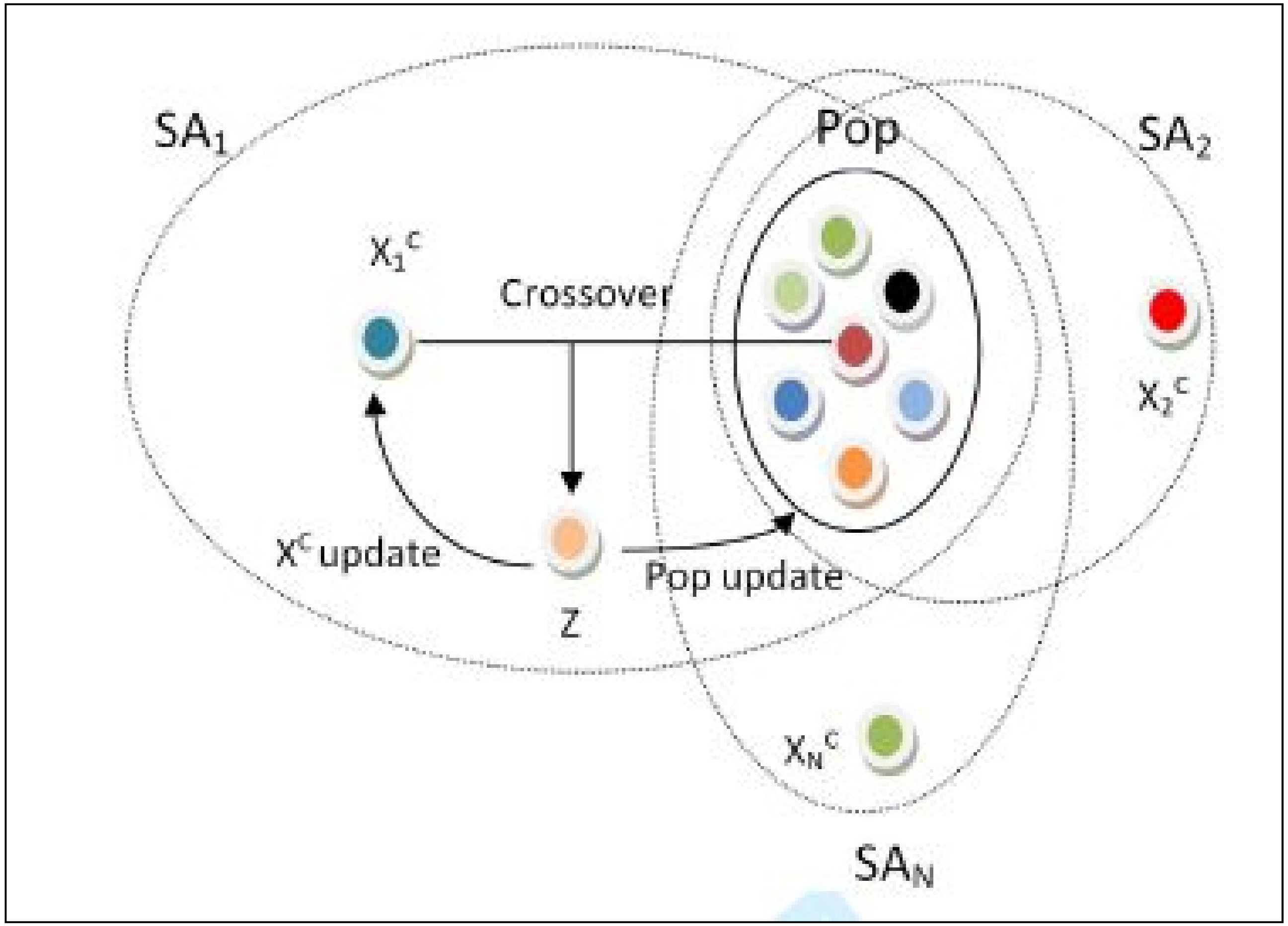


Fig. 7. EA with SA-based components.

Hybrid MHs based on EAs and Simulated Annealing



Hybrid MHs based on EAs and SA
Resultados

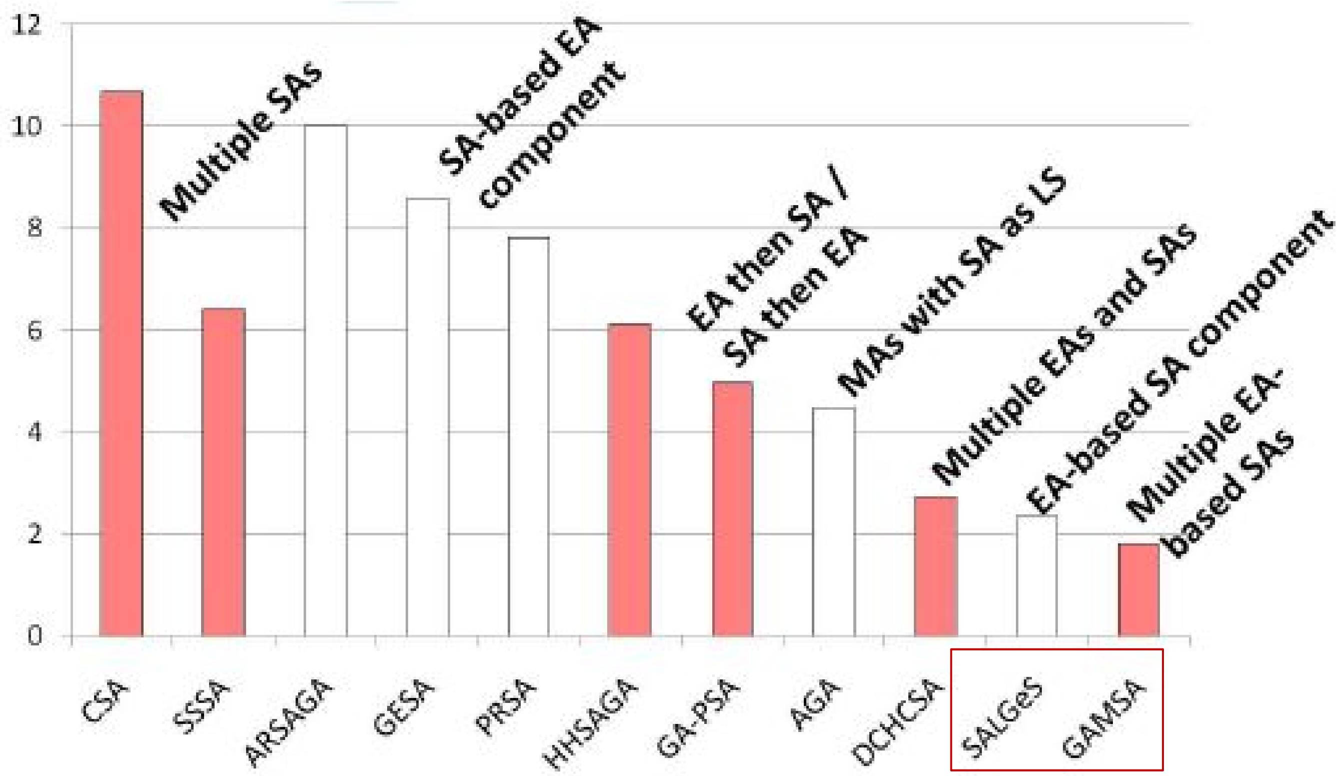


Fig. 13: Average rankings of the HMs-EA/SA versions

Hybrid MHs based on EAs and Simulated Annealing. Test de Sinergia

HMs	Single Metah.	Comp. on Results			Comp. on Time		
		R^+	R^-	Diff	R^+	R^-	Diff
CSA	SA	0	378	–	64	314	–
	CGGA	0	378	–	321	57	+
	CSSGA	100	278	–	358	20	+
	CHC	0	378	–	309	69	+
ARSAGA	SA	0	378	–	24	354	–
	CGGA	0	278	–	262	116	~
	CSSGA	16	362	–	60	318	–
	CHC	0	378	–	277	101	+
GESA	SA	0	378	–	38	340	–
	CGGA	0	378	–	298	80	+
	CSSGA	4	374	–	378	0	+
	CHC	0	378	–	301	77	+
PRSA	SA	0	378	–	27	351	–
	CGGA	10	368	–	288	90	+
	CSSGA	0	378	–	279	99	+
	CHC	1	377	–	277	101	+
SSSA	SA	0.5	377.5	–	48	330	–
	CGGA	33.5	344.5	–	329	49	+
	CSSGA	378	0	+	378	0	+
	CHC	1	377	–	367	11	+
HHSAGA	SA	8	370	–	116	262	~
	CGGA	88	290	–	378	0	+
	CSSGA	377	1	+	378	0	+
	CHC	46	332	–	378	0	+
GA-PSA	SA	7.5	370.5	–	68	310	–
	CGGA	0	378	–	359.5	18.5	+
	CSSGA	158.5	219.5	~	210	168	~
	CHC	52.5	325.5	–	355	23	+
AGA	SA	30.5	347.5	–	81	297	–
	CGGA	237.5	140.5	~	339	39	+
	CSSGA	378	0	+	323	55	+
	CHC	129.5	248.5	~	345	33	+
DCHCSA	SA	206.5	171.5	~	32	346	–
	CGGA	330.5	47.5	+	276	102	+
	CSSGA	378	0	+	306	72	+
	CHC	328.5	49.5	+	325	53	+
SALGeS	SA	287.5	90.5	+	27	352	–
	CGGA	374.5	3.5	+	174	204	~
	CSSGA	378	0	+	192	186	~
	CHC	343.5	34.5	+	160	218	~
GAMSA	SA	277.5	101.5	+	27	351	–
	CGGA	352.5	25.5	+	188	190	~
	CSSGA	378	0	+	214	164	~
	CHC	333.5	44.5	+	199	179	~

Metaheurísticas Specializing in I&D

*Some MHs show certain **specialization** in intensification or diversification.*

- ***Diversification** refers to the ability to visit many and different regions of the search space*
- ***Intensification** refers to the ability to obtain high quality solutions within those regions.*

Hybrid MHs with search algorithms specializing in I&D:
They combine this type of algorithms with the objective of compensating each other and put together their complementary behaviors (exploration and exploitation).

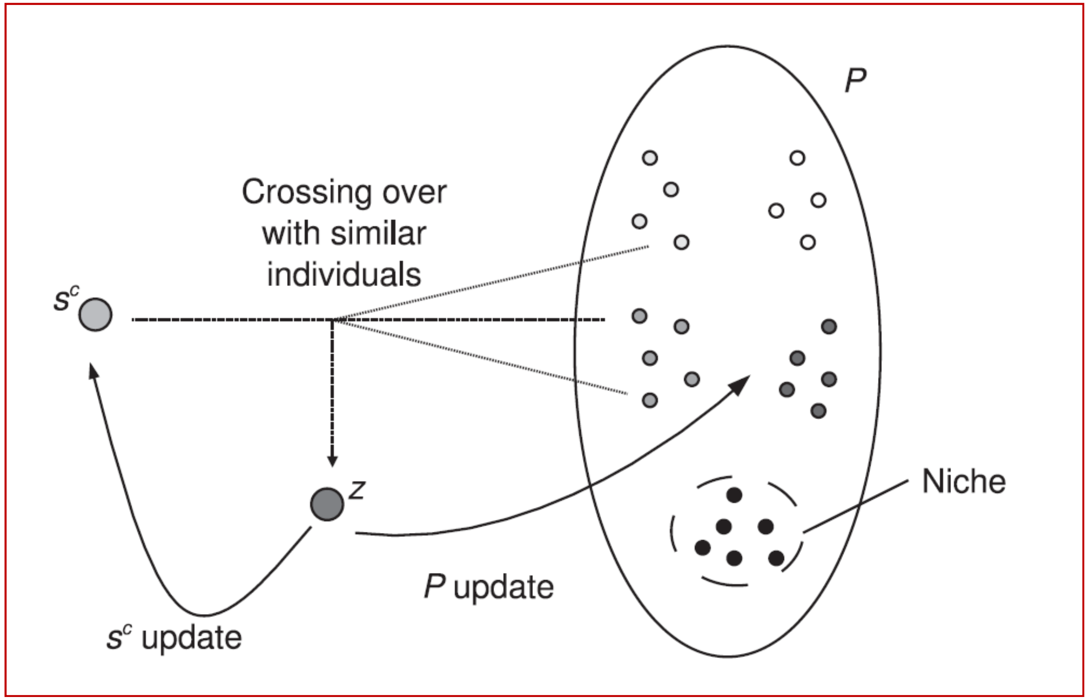
EAs Specializing in I&D

The flexibility offered by the EA paradigm allows ***specialized*** *models to be obtained with the aim of providing intensification and/or diversification*

$\text{HMH-EA}_{\text{I\&D}}$ ***Hybrid MHs with EAs specializing in I&D****.*

M. Lozano, C. García-Martínez. Hybrid Metaheuristics with Evolutionary Algorithms Specializing in Intensification and Diversification: Overview and Progress Report. Computers & Operations Research 37 (2010) 481 - 497

Binary-Coded Local GA



C. García-Martínez, M. Lozano. Evaluating a Local Genetic Algorithm as Context-Independent Local Search Operator for Metaheuristics. Soft Computing 14:10 (2010) 1117-1139.

Evolutionary ILS-Perturbation