Comparison of variation operators and survival strategies

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Teaching Learning Based Optimization (TLBO)

- Teacher phase:

$$X_{new} = X_i + r\left(X_{best} - T_f X_{mean}\right)$$

- Learner phase:

$$X_{new} = \begin{cases} X_i + r\left(X_i - X_p\right) & if\ \ f_i < f_p \\ X_i - r\left(X_i - X_p\right) & otherwise \end{cases}$$

X	Current solution
X_{new}	New solution
X_{best}	Teacher
X_{mean}	Mean of the population
T_f	Teaching factor, either 1 or 2
r	Random numbers between 0 and 1
Xp	Partner solution
f_i	Fitness of current solution
f_p	Fitness of partner solution

Particle Swarm Optimization (PSO)

➢Particle velocity

$$v_i = wv_i + c_1 r_1 \left(p_{best,i} - X_i \right) + c_2 r_2 \left(g_{best} - X_i \right)$$

➢Position of particle

$$X_i = X_i + v_i$$

v_i	Velocity of the i^{th} particle
w	Inertia of the particles
c_1 and c_2	Acceleration coefficients
r_1 and r_2	Random numbers [0,1] of size (1x*D*)
$p_{best,i}$	Personal best of i^{th} particle
g_{best}	Global best
X_i	Position of i^{th} particle

Differential Evolution (DE)

➢Donor vector using DE/rand/1 mutation strategy

$$V = X_{r_1} + F\left(X_{r_2} - X_{r_3}\right)$$

F	Scaling factor, a constant between 0 and 2
r_1, r_2, r_3	Random solutions $r_1, r_2, r_3 \in \{1, 2, 3, \ldots, N_p\}$ *and* $r_1 \neq r_2 \neq r_3 \neq i$ where *i* is the index of current solution

➢Trial vector using binomial crossover

$$u^j = \begin{cases} v^j & \text{if } r \le p_c \text{ OR } j = \delta \\ x^j & \text{if } r > p_c \text{ AND } j \neq \delta \end{cases}$$

p_c	crossover probability
δ	randomly selected variable location $\delta \in \{1, 2, 3, \ldots, D\}$
r	random number between 0 and 1
u^j	j^{th} variable of trial vector
v^j	j^{th} variable of donor vector
x^j	j^{th} variable of target vector

Genetic Algorithm (GA)

➢Offspring generated using SBX crossover

$$\beta = \begin{cases} (2u)^{1/(\eta_c+1)} & if\ u \le 0.5 \\ \left(\dfrac{1}{2(1-u)}\right)^{1/(\eta_c+1)} & otherwise \end{cases}$$

$$\left.\begin{aligned} O_a &= 0.5\left[(1+\beta)P_a^{'} + (1-\beta)P_b^{'}\right] \\ O_b &= 0.5\left[(1-\beta)P_a^{'} + (1+\beta)P_b^{'}\right] \end{aligned}\right\} if\ r_c < p_c$$

r_c and u are random numbers between 0 and 1

p_c is the crossover probability

η_c is distribution index

$P_a^{'}$	Parent 1	O_a	Offspring 1
$P_b^{'}$	Parent 2	O_b	Offspring 2

➢Offspring generated (if $r_m < p_m$) using polynomial mutation

$$\delta = \begin{cases} (2r)^{1/(\eta_m+1)} - 1 & \text{if } r < 0.5 \\ 1 - \left[2(1-r)\right]^{1/(\eta_m+1)} & \text{if } r \ge 0.5 \end{cases}$$

$$O = O + (ub - lb)\delta \ \ if\ r_m < p_m$$

r_m and r are random numbers between 0 and 1

p_m is the mutation probability

η_m is distribution index

O	Offspring solution
ub	upper bound
lb	lower bound

Artificial Bee Colony (ABC)

- Employed bee phase

$$X_{new}^{j} = X^{j} + \phi\left(X^{j} - X_{p}^{j}\right)$$

- Onlooker bee phase

$$prob_i = 0.9\left(\frac{fit_i}{\max\left(fit\right)}\right) + 0.1$$

$$X_{new}^{j} = X^{j} + \phi\left(X^{j} - X_{p}^{j}\right) \ \ if \ \ r < prob_i$$

- Scout bee phase

$$X_k = lb + \left(ub - lb\right)r \quad if \ \ \max trial_k > limit$$

X^j	j[th] variable of solution X
X_p^j	j[th] variable of partner solution
$prob_i$	Probability of i[th] solution
fit_i	Fitness of i[th] solution
ϕ	Random number between -1 and 1
r	Random numbers between 0 and 1
lb	Lower bound of decision variable
ub	Upper bound of decision variable

Equations used for variation

TLBO

$$X_{new} = X_i + r\left(X_{best} - T_f X_{mean}\right)$$

$$X_{new} = \begin{cases} X_i + r\left(X_i - X_p\right) & if\ f_i < f_p \\ X_i - r\left(X_i - X_p\right) & otherwise \end{cases}$$

PSO

$$v_i = wv_i + c_1 r_1\left(p_{best,i} - X_i\right) + c_2 r_2\left(g_{best} - X_i\right)$$

$$X_i = X_i + v_i$$

DE

$$V = X_{r_1} + F\left(X_{r_2} - X_{r_3}\right)$$

$$u^j = \begin{cases} v^j & if\ r \le p_c\ OR\ j = \delta \\ x^j & if\ r > p_c\ AND\ j \ne \delta \end{cases}$$

GA

$$\beta = \begin{cases} (2u)^{1/(\eta_c+1)} & if\ u \le 0.5 \\ \left(\dfrac{1}{2(1-u)}\right)^{1/(\eta_c+1)} & otherwise \end{cases}$$

$$\left.\begin{aligned} O_a &= 0.5\left[(1+\beta)P_a' + (1-\beta)P_b'\right] \\ O_b &= 0.5\left[(1-\beta)P_a' + (1+\beta)P_b'\right] \end{aligned}\right\} if\ r_c < p_c$$

$$\delta = \begin{cases} (2r)^{1/(\eta_m+1)} - 1 & \text{if } r < 0.5 \\ 1 - \left[2(1-r)\right]^{1/(\eta_m+1)} & \text{if } r \ge 0.5 \end{cases}$$

$$O = O + (ub - lb)\delta \ \ if\ r_m < p_m$$

ABC

$$X_{new}^j = X^j + \phi\left(X^j - X_p^j\right)$$

$$prob_i = 0.9\left(\frac{fit_i}{\max(fit)}\right) + 0.1$$

$$X_{new}^j = X^j + \phi\left(X^j - X_p^j\right) \ \ if\ r < prob_i$$

$$X_k = lb + (ub - lb)r \ \ \ if\ \max trial_k > limit$$

Survival strategy

Old Solution		New Solution		Greedy strategy		(μ, λ) strategy		(μ + λ) strategy	
Sol	**f**	**Sol**	**f**	**Sol**	**f**	**Sol**	**f**	**Sol**	**f**
[3 1]	10	[4 3]	25	[3 1]	10	[4 3]	25	[1 0]	1
[1 5]	26	[1 2]	5	[1 2]	5	[1 2]	5	[2 0]	4
[3 3]	18	[4 2]	20	[3 3]	18	[4 2]	20	[1 2]	5
[2 0]	4	[1 0]	1	[1 0]	1	[1 0]	1	[3 1]	10
[4 1]	17	[3 1]	10	[3 1]	10	[3 1]	10	[3 1]	10
		Algorithms →		TLBO DE ABC (except scout phase)		PSO Scout phase of ABC		GA	

Thank You !!!