Fundamental Evolutionary Algorithm for Real Domain Optimization

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The problem of this report is about different evolutionary algorithms to solve **the single-objective optimization problem** (minimization specifically) for some benchmark functions in **real domain variable**, formulated as:

$$f : \mathbb{R}^D \rightarrow \mathbb{R} \tag{1}$$

$$\arg\min_x f(x) \quad \text{subject to} \quad x_i \in [B^i_{\min}, B^i_{\max}], \quad \forall i = 1, \ldots, D \tag{2}$$

where $B^i_{\min}$ and $B^i_{\max}$ are the lower and upper bounds of the variable x in the ith dimension.

1 GENETIC ALGORITHM (GA)

Algorithm 1 Genetic Algorithm with Tournament Selection

Input: f (the function to be minimized), D (dimension of the variable), B (the bounds of each dimension), C_r (the probability to mutate a candidate), N (Population size - **even number**),
Output: x , $f(\mathbf{x})$ (The solution of problem)
Initialize population $X \leftarrow \{x_0, x_1, x_2, ..., x_{N-1}\}$
while stop condition not met **do**
    $P \leftarrow X$
    while $i = 0 \rightarrow 1$ **do**
        $p_1, p_2 \leftarrow$ RandomChoice(X)
        $o_1, o_2 \leftarrow$ Crossover(p_1, p_2)
        if Random(0, 1) < C_r **then**
            $o_1 \leftarrow$ Mutate(o_1)
        end if
        if Random(0, 1) < C_r **then**
            $o_2 \leftarrow$ Mutate(o_2)
        end if
        $o_1, \leftarrow$ clip(o_1, B)
        $o_2, \leftarrow$ clip(o_2, B)
        $P = P \cup \{o_1, o_2\}$
    end while
    $X \leftarrow$ TournamentSelection(P, N, f)
end while
$\mathbf{x} = \arg\min_x(f(X))$
return $\mathbf{x}$, $f(\mathbf{x})$

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Algorithm 2 Tournament Selection

Input: P (the pool of candidates), N (population size), f (the function to be minimized), D (dimension of the variable)
Output: X **(The selected population)**
$X \leftarrow \{\}$
while $i = 0 \rightarrow 1$ **do**
    $P \leftarrow \text{Shuffle}(P)$
    while $j = 0 \rightarrow 2N$ **do**
        $x \leftarrow \arg\min_x \{f(P_k) \mid P_k \in P[0:4]\}$
        $X \leftarrow X \cup x$
        $j \leftarrow j + 4$
    end while
end while
return X

2 DIFFERENCIAL EVOLUTIONARY (DE)

Algorithm 3 Differencial Evolution

Input: f (the function to be minimized), D (dimension of the variable), B (the bounds of each dimension), C_r (the probability to crossover a candidate), N (Population size - **even number**), F (Scaling Factor)
Output: x , $f(\mathbf{x})$ (The solution of problem)
Initialize population X $\{x_0, x_1, x_2, ..., x_{N-1}\}$
while stop condition not met **do**
    while $i \rightarrow N$ **do**
        $r_1, r_2, r_3 \leftarrow \text{RandomChoice}(X)$
        $v \leftarrow x_1 + F(x_2 - x_3)$
        $v \leftarrow \text{clip}(v, B)$
        $j \leftarrow \text{Random}(0, D)$
        $u \leftarrow X[i]$
        while $k \rightarrow D$ **do**
            if $\text{Random}(0, 1) < C_r$ or $k = j$ **then**
                $u_{(k)} = v_{(k)}$
            end if
        end while
    end while
end while

3 PARTICAL SWARM OPTIMIZATION (PSO)

Algorithm 4 Partical Swarm Optimization

Input: f (the function to be minimized), D (dimension of the variable), B (the bounds of each dimension), C_r (the probability to crossover a candidate), N (Population size - **even number**)
Output: x , $f(\mathbf{x})$ (The solution of problem)
Initialize population X $\{x_0, x_1, x_2, ..., x_{N-1}\}$
Initialize velocity V $\{v_0, v_1, v_2, ..., v_{N-1}\}$
$w \leftarrow 0.5, c_1 \leftarrow 1.5, c_2 \leftarrow 1.5$
$P^* \leftarrow X, p^* \leftarrow \arg\min_x(f(X))$
while stop condition not met **do**
    $r_1, r_2 \leftarrow \text{RandomChoice}(X)$
    while $i \rightarrow N-1$ **do**
        $V[i] \leftarrow wV[i] + c_1 r_1(P^*[i] - X[i]) + c_2 r_2(p^* - X[i])$
    end while
    $X \leftarrow \text{clip}(X + V, B)$
    while $i \rightarrow N-1$ **do**
        if $f(X[i]) < f(P[i])$ **then**
            $P^*[i] = X[i]$
        end if
    end while
    if $\min(f(X)) < f(p^*)$ **then**
        $p^* \leftarrow \arg\min_x f(X)$
    end if
end while
return $p^*, f(p^*)$

REFERENCES