Brief description of hunger games search (HGS) optimization

1 Approach food

To express its approaching behavior in mathematical formulas, the following formulas are proposed to imitate the contraction mode:

$$\overrightarrow{X(t+1)}=\begin{cases}\overrightarrow{X(t)}\cdot(1+randn(1)), & r_1<l\\ \overrightarrow{W_1}\cdot\overrightarrow{X_b}+\vec{R}\cdot\overrightarrow{W_2}\cdot\left|\overrightarrow{X_b}-\overrightarrow{X(t)}\right|, & r_1>l, r_2>E\\ \overrightarrow{W_1}\cdot\overrightarrow{X_b}-\vec{R}\cdot\overrightarrow{W_2}\cdot\left|\overrightarrow{X_b}-\overrightarrow{X(t)}\right|, & r_1>l, r_2<E\end{cases} \tag{1}$$

where $\vec{R}$ is in the range of $[-a,a]$; r_1 and r_2 respectively represent random numbers, which are in the range of $[0,1]$; $randn(1)$ is a random number satisfying normal distribution; t indicates that the current iterations; $\overrightarrow{W_1}$ and $\overrightarrow{W_2}$ represent the weights of hunger; $\overrightarrow{X_b}$ represents the location information of a random individual in all the optimal individuals; $\overrightarrow{X(t)}$ represents each individual's location; and the value of l has been discussed in the parameter setting experiment.

The formula of E is as follows:

$$E=\operatorname{sech}(|F(i)-BF|) \tag{2}$$

where $i\in 1,2,\ldots,n, F(i)$ represents the fitness value of each individual; and BF is the best fitness obtained in the current iteration process. Sech is a hyperbolic function $\left(\operatorname{sech}(x)=\frac{2}{e^x+e^{-x}}\right)$.

The formula of $\vec{R}$ is as follows:

$$\vec{R}=2\times a\times rand-a \tag{3}$$

$$a=2\times\left(1-\frac{t}{Max\_iter}\right) \tag{4}$$

where $rand$ is a random number in the range of $[0,1]$; and Max_iter stands for the largest number of iterations.

2 Hunger role

The starvation characteristics of individuals in search are simulated mathematically.

The formula of $\overrightarrow{W_1}$ in **Eq. (5)** is as follows:

$$\overrightarrow{W_1(i)}=\begin{cases}hungry(i)\cdot\frac{N}{SHungry}\times r_4, & r_3<l\\ 1 & r_3>l\end{cases} \tag{5}$$

The formula of $\overrightarrow{W_2}$ in **Eq. (6)** is shown as follows:

$$\overrightarrow{W_2(i)}=(1-exp(-|hungry(i)-SHungry|))\times r_5\times 2 \tag{6}$$

where $hungry$ represents the hunger of each individual; N represents the number of individuals; and $SHungry$ is the sum of hungry feelings of all individuals, that is $sum(hungry)$. r_3, r_4 and r_5 are random numbers in the range of $[0,1]$.

The formula for $hungry(i)$ is provided below:

$$hungry(i) = \begin{cases} 0, & AllFitness(i) == BF \\ hungry(i) + H, & AllFitness(i)! = BF \end{cases} \tag{7}$$

where $AllFitness(i)$ preserves the fitness of each individual in the current iteration.

The formula for H can be seen as follows:

$$TH = \frac{F(i) - BF}{WF - BF} \times r_6 \times 2 \times (UB - LB) \tag{8}$$

$$H = \begin{cases} LH \times (1 + r), & TH < LH \\ TH, & TH \geq LH \end{cases} \tag{9}$$

where r_6 is a random number in the range of $[0,1]$; $F(i)$ represents the fitness value of each individual; BF is the best fitness obtained in the current iteration process; *WF* stands for the worst fitness obtained in the current iteration process; and UB and LB indicate the upper and lower bounds of the search space, respectively. The hunger sensation H is limited to a lower bound, LH.

Algorithm 1 Pseudo-code of HGS

Initialize the parameters N, $Max\_iter, l, D, SHungry$
Initialize the positions of Individuals $X_i (i = 1,2, \ldots, N)$
While ($t \leq Max\_iter$)
    Calculate the fitness of all Individuals
    $Update\ BF, WF, X_b, BI$
    Calculate the $Hungry$ by **Eq.** (7)
    Calculate the W_1 by **Eq.** (5)
    Calculate the W_2 by **Eq.** (6)
    For $each\ Individuals$
        Calculate E by **Eq.** (2)
        $Update\ R$ by **Eq.** (3)
        $Update\ positions\ by$ **Eq.** (1)
    End For
    $t = t + 1$
End While
Return BF, X_b

Reference

Yutao Yang, Huiling Chen, Ali Asghar Heidari, Amir H Gandomi, **Hunger Games Search: Visions, Conception, Implementation, Deep Analysis, Perspectives, and Towards Performance Shifts**, Expert Systems with Applications,2021,114864, https://doi.org/10.1016/j.eswa.2021.114864 (https://www.sciencedirect.com/science/article/pii/S0957417421003055)