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:

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

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:

$$E = \text{sech}(|F(i) - BF|) \quad (2)$$

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 $\left(\text{sech}(x) = \frac{2}{e^x + e^{-x}}\right)$.

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

$$\vec{R} = 2 \times a \times rand - a \quad (3)$$

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

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:

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

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

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

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:

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

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

The formula for H can be seen as follows:

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

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

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 $X_i (i = 1,2, \dots, N)$
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)