Bondarenko D.V., Nikitina A.V. (Don State Technical University, Rostov-on-Don)
Evaluation of the effectiveness of heuristic optimization methods with a random distribution of input data

Define some function $f : R^n \to R$, for which it is necessary to find the extremum points depending on the task, and the search area $S = [s_1^0; s_1^1] \times \ldots \times [s_n^0; s_n^1] \subset R^n$. Next, the initial harmonics $\{h_i \in S\}_{i=1}^k$ are randomly generated in a given area, where k is a value indicating the number of harmonics that can be stored in memory. Let in the algorithm p_c be the probability of choosing from memory harmonics, p_m – the probability of modification and bw is the magnitude of the modification. The iterative part of the algorithm continues until its stop criterion is met. The criterion may be a limitation on the number of iterations, on the number of predictions without updating the harmonics memory, or the proximity of the harmonics being added according to a given metric. When implementing the first step of the iterative part of the algorithm, a new zero harmonic is created $h_{new} = \{0, 0, \ldots, 0\} \in R^n$. Then, for each harmonic component, a random number ϵ is generated, evenly distributed in the interval (0,1). If ϵ is less than p_c, then the corresponding component from a randomly selected harmonic located in memory is written to the current component, otherwise the component is generated randomly, taking into account the belonging of the component from the search area S. If the component was generated using internal or external memory, then it is probably necessary to modify it. To do this, a random number ϵ is generated, again evenly distributed in the interval (0,1). If ϵ is less than p_m, then the component changes by the value $\delta \cdot bw$, where δ is a random variable located on the segment [-1;1]. If $f(h_{new}) < \max\limits_{1 \le i \le k} f(h_i)$, then h_{new} replaces $arg \max\limits_{1 \le i \le k} f(h_i)$. To test the algorithm, the distribution function of the concentration of the pollutant in the reservoir was used [2]:

$$C(x,y) = \begin{cases} sin(\pi(x-10)/10)sin(\pi(y-10)/10), (x,y) \in D, \\ 0, (x,y) \notin D, D = \{(x,y) \in R^2 : x \in [10,20], y \in [10,20]\}. \end{cases}$$

For the harmonic search method, we set the algorithm stop parameter in the form of a limit on the number of improvisations in the iterative part, equal to 10000. The number of harmonics that can be stored in memory is set to 100. The operating time of the software module implementing the test task in the Python programming language was 0.496674 seconds. The result of the algorithm for the test problem under consideration will be finding the best harmonic [15.000570810442545, 14.99912225607023] with a function value of 0.9999999459017892.

The considered heuristic algorithm is a zero-order method, it is based on harmonics and improvisation of musicians, which greatly simplifies its understanding. Using the idea of modifying a vector with a probabilistic approach makes it possible to reduce the possibility that when finding the extremum points of a function, a closure to its local extremum points will occur.

REFERENCES

1. *Zong Woo Geem* Music-Inspired Harmony Search Algorithm. Studies in Computational Intelligence (SCI, volume 191) DOI:10.1007/978-3-642-00185-7

2. *Atayan, A.M., Nikitina, A.V., Sukhinov, A.I., Chistyakov, A.E.* Mathematical Modeling of Hazardous Natural Phenomena in a Shallow Basin (2022) Computational Mathematics and Mathematical Physics, 62 (2), pp. 269-286.
DOI: 10.31857/S0044466921120048

*The study was financially supported by the Grants Council of the President of the Russian Federation within the framework of the scientific project No. MD-3624.2021.1.1