Georgian Scientists
ქართველი მეცნიერები
Vol. 5 Issue 4, 2023
https://doi.org/10.52340/gs.2023.05.04.25

The effectiveness of the Hooke-Jeeves method in the experiment under error conditions is assessed

Nona Otkhozoria[1]; Medea Narchemashvili[2]; Vano Otkhozoria[3]
[1]Georgian Technical University; https://orcid.org/0000-0002-5837-5345
[2]Georgian Technical University; [3]Georgian Technical University https://orcid.org/0009-0008-6028-3758

Abstract

In summary, this study investigates the effectiveness of the Hooke-Jeeves method, an extremum search technique, in the presence of experimental errors. The study involves modeling the Hooke-Jeeves method algorithm and examining how experimental errors impact extremum search efficiency under various step conditions.

Key words: Hooke-Jeeves, extremum point

Introduction

Among the zero-order methods, the Hooke-Jeeves method stands out as one of the most popular and effective approaches. The search process comprises several key procedures:

Examining the base point and identifying patterns at the base point.

Conducting research, also referred to as "exploratory search" in some literature, with a focus on determining the local behavior of the objective function and the presence of a "valley" by establishing the direction.

Utilizing the obtained information for sampling during a search, particularly while navigating through the Heavy area [1].

While this method proves effective in error-free experiments, real-world situations often involve measurement errors that impact search results [2]. To carry out a research search, it is crucial to choose the size of the BZ, which may vary across different coordinate directions. However, this size undergoes changes throughout the search process.

If the objective function's value at the base point does not surpass its value at the starting point, the search move is considered successful. Otherwise, it is necessary, as mentioned in the preceding paragraph, to select a return and reverse direction. This process continues for all coordinate options N until the search is completed, resulting in the identification of the base point.

Main Part

Pattern search involves implementing a single base point along the way, and the determination of a new sampling point follows a specific formula:

$$x^{(k+1)}p = x^{(k)} + (X^{(k)} - X^{(k-1)})$$

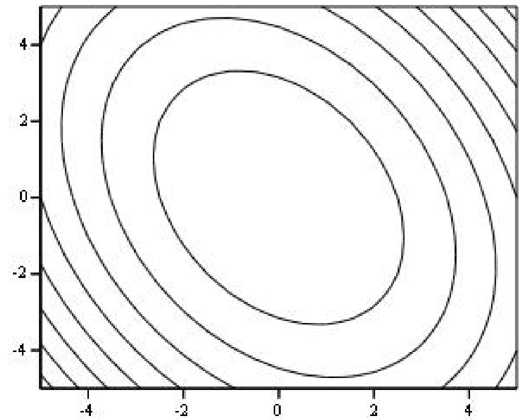

Figure 1 The graph of the function and contour curves

Once movement along the pattern fails to result in a decrease (or increase) in the objective function, the point $x^{(k+1)}p$ is designated as a temporary base point, and the search process is reiterated. If, during this search, a point is identified with a corresponding objective function value lower (or higher) than that of the current base point $x^{(k)}$, the point $x^{(k+1)}$is considered the new base point. In cases where the exploratory search proves unsuccessful, it is essential to backtrack to the previous point and continue the exploratory search to identify a new optimal direction.

In the event of an unsuccessful research attempt, it becomes necessary to decrease the life expectancy by introducing a specific multiplier and subsequently resume the search for research. The sequence of points resulting from the method's implementation can be described as follows: $x^{(k)}$ - the current base point, $x^{(k-1)}$- the previous base point, $x^{(k+1)}p$ - the point obtained during movement along the template, and $x^{(k+1)}$- the next (new) base point.

Various implementations of the Hooke-Jeeves method exist, differing in both the criterion for concluding the search and the strategy employed to find the extremum point, where any one-dimensional search method is utilized. Naturally, depending on the chosen solution option, the final result is achieved with a varying number of iterations [1].

The Hooke-Jeeves algorithm is regarded as one of the effective methods, surpassing its predecessors. The information acquired during each iteration is harnessed to expedite the search process. We employed the Hooke-Jeeves method to search for surfaces defined by the equation: $f(x, y) = 8x^2 + 4xy + 5y^2$

The visual representation of the surfaces and their corresponding contour curves is provided in Fig.1

We conducted an experiment with varying values of the step reduction coefficient, utilizing ε=0.0001 as the search termination parameter [3]. In other words, the search was concluded when the step value fell below 0.0001 (1). The results obtained from the surface examination are presented in Table 1.

step reduction coefficient α	number of tests	X	y	f
Search if there are no errors				
2	34	0	0	0
5	18	0	0	0
10	14	0	0	0
ξ = 2%				
2	43	0	0	-0,019
5	25	0	0	-0,0058
10	16	0	0	-0,0068
ξ = 5%				
2	43	0,000977	0,002441	-0,0478
5	25	0,008	0,0192	-0,0161
10	16	0,001	0	-0,017
ξ = 10%				
2	46	0,033	0,036	-0,0767
5	25	0,008	0,0192	-0,0334
10	16	0,001	0	-0,0345
ξ = 20%				
2	46	0,033	0,036	-0,143
5	25	0,008	0,0192	-0,068
10	16	0,001	0	-0,069

Analysis of the results indicates that the impact of errors in determining the function minimum is negligible when ξ = 2%, with the objective function value experiencing an average shift of 0.02. For ξ = 5%, 10%, and 20%, the displacement of x and y values corresponds to (0.003326; 0.007214), (0.014;

0.0184), and (0.014; 0.0184), respectively. The average displacement of the objective function values for these cases is 0.02704, 0.04824, and 0.10314, respectively. To achieve optimal results in error-prone conditions, it is necessary to conduct, on average, twice as many trials.

Conclusion

In conclusion, the research findings suggest that employing the Hooke-Jeeves method for minimizing with a small step size (ξ = 10%, 20%) in the presence of additive errors is effective. Furthermore, under conditions with significant deviations, it is observed that the impact of errors diminishes as the step size increases.

გამოყენებული ლიტერატურა

1. Jibladze N., Topchishvili A. (2001). Numerical methods of statistical optimization. Management Systems Institute. Tbilisi (in Georgian)

2. Chkheidze I., Otkhozoria V., Narchemashvili M., Khorava Sh. (2021). Measurement quality Assessment. Transact. of GTU "Automated Control Systems", No 1(32), Vol.1.2. Tbilisi, pp.306-310 (in Georgian)

3. Nona Otkhozoria, Vano Otkhozoria, & Shorena Khorava. (2022). Search for an extremum using the steepest descent method under the conditions of experimental errors. World Science, (2(74). https://doi.org/10.31435/rsglobal_ws/28022022/7785

ჰუკი-ჯივსის მეთოდის ეფექტურობის შეფასება ექსპერიმენტის შეცდომების პირობებში

ნონა ოთხოზორია, მედეა ნარჩემაშვილი, ვანო ოთხოზორია

საქართველოს ტექნიკური უნივერსიტეტი

აბსტრაქტი

სტატიაში გამოკვლეულია ჰუკი-ჯივსის მეთოდით ექსტრემუმის პოვნის პრობლემები ექსპერიმენტის შეცდომების არსებობისას. კვლევა მოიცავს ჰუკი-ჯივის მეთოდის ალგორითმის მოდელირებას და იმის შესწავლას, თუ რა გავლენას ახდენს ექსპერიმენტული შეცდომები ექსტრემუმის პოვნის სიზუსტეზე, განხილულია შეცდომების სხვადასხვა დონეები და შეფასებულია ძიების სიზუსტის ინტერვალი.

საკვანძო სიტყვები: ჰუკი-ჯივსი, ექსტრემუმის წერტილი.