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ANALYSIS OF EFFICIENCY AND COMPLEXITY OF ALGORITHMS

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Анотація
У даній статті розглянуто особливості оцінювання ефективності та складності алгоритмів.
Ключові слова: *алгоритм; ефективність; часова складність; ресурси; функція.*

Abstract
This article discusses the features of evaluating the effectiveness and complexity of algorithms.
Key words: algorithm; efficiency; complexity; resources; function.

An algorithm is a system of calculations performed according to strictly defined rules, which after a finite number of steps, leads to the solution of the problem [1].

Usually, each algorithm is associated with an intuitive idea of its complexity and efficiency. However, this representation does not allow you to unambiguously choose to solve a particular problem from one of the many equivalent algorithms or to determine the possibility of using this algorithm to solve it. Therefore, it is important to formalize the evaluation of the complexity and efficiency of algorithms.

Algorithm efficiency is a property of an algorithm associated with the computing resources used by the algorithm. To maximize efficiency, it is desirable to reduce resource use. However, different resources (such as time and memory) cannot be compared directly, so which of the two algorithms is considered more efficient often depends on which factor is more important, such as high-speed requirements, minimal memory usage, or other efficiency measures.

Algorithm complexity is a time estimate of the algorithm's performance and the amount of memory required to execute it using some abstract computer.

As resources can be considered human (to create and understand the algorithm) and computing resources. Therefore, there are descriptive (intellectual) and computational complexity of the algorithm. Descriptive complexity is determined based on the record (text) of the algorithm. There is no single criterion for its evaluation. Typically, the descriptive complexity is characterized by the length and clarity of the algorithm record.

Memory and processor time are considered as computing resources for algorithm execution. Therefore, the main measures of the computational complexity of the algorithms are:

- capacitive (spatial) complexity, which characterizes the amount of memory required to perform the algorithm;
- time complexity, which characterizes the amount of time required to perform the algorithm (this time is usually determined by the number of basic operations that must be performed to implement the algorithm).

The running time of any algorithm depends on the amount of input data. So, for example, when the sorting algorithm works, the time depends on the size of the input array. In general, the dependence of the algorithm operation time on the input size is studied. In some problems, the size of the input data is the number of elements at the input. In other cases, the input size is the total number of bits needed to represent all the input data [2].

The time characteristic (physical execution time) of the algorithm complexity is the value $\tau \cdot t$, where t is the number of algorithm actions (elementary commands), and τ is the average execution time of one operation (command). The number of commands t is determined by the description of the algorithm in a particular algorithmic model and does not depend on the physical implementation of this model. The average time τ is a physical value that depends on the processing speed of the signals in the PC elements. Therefore, the objective mathematical characteristic of the complexity of the algorithm in a particular model is the number of commands *t*.

The capacitive characteristic of the complexity of algorithms is determined by the number of memory cells used in the calculation process. This value cannot exceed the number of actions t multiplied by a certain constant (the number of cells used when executing one command).

It should be noted that the time complexity of the algorithm is not a constant value and depends on the dimension of the problem.

In this case, the complexity of the algorithm (both temporal and capacitive) is described by the function f (n), where n is the size of the input data (dimension of the processed array, number of words in the analyzed text, length of the sequence in the algorithm, number of vertices, etc.).

Usually, a slower algorithm always works, and a faster algorithm only works under certain conditions [3]. The complexity and efficiency of different classes of algorithms are shown in Figure 1.

N	$O(\log_2 n)$	$O(n)$	$O(n\log_2 n)$	$O(n^2)$	$O(2^n)$	$O(n!)$	$O(n^n)$
1	0	1	0	1	2	1	1
5	2,3219	5	11,6069	25	32	120	3,125
10	3,3219	10	33,2193	100	1,024	$3{,}6*10^6$	10^{10}
20	4,3219	20	86,4386	400	10^6	$2{,}4*10^{18}$	10^{26}
30	4,9069	30	147,2067	900	10^9	$2{,}6*10^{32}$	$2*10^{44}$
100	6,6439	100	664,3856	10000	10^{30}	10^{51}	10^{200}

Figure 1 - Comparison of the efficiency of algorithms

Therefore, the time required by the algorithm to solve the problem, which is a function of the size of the input data (problem size, task), is called the time complexity of the algorithm. The limiting behavior of increasing complexity, depending on the size, is called asymptotic temporal complexity. Similarly, the memory algorithm complexity (capacitive complexity) and the asymptotic complexity (asymptotic capacitive complexity) of the memory algorithm can be determined. It is clear that even for modern computers with huge memory and speed, such characteristics of algorithms are and will be relevant [4].

Conclusion

The analysis has shown that the algorithms are used to reduce the complexity of solving the problem by finding a more efficient algorithm.

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