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RESEARCH ON VARIOUS TYPES OF ARRAYS IN C++

Aslonov Qodir Ziyodullayevich
Asia International University

Abstract: This scientific article analyzes arrays in the C++ programming language, their types, characteristics, application areas, and efficiency. One-dimensional, two-dimensional, multi-dimensional, dynamic arrays, and comparisons with STL containers are presented. The structure of arrays, memory management, indexing mechanisms, and algorithmic complexity are examined. In addition, advantages and disadvantages of arrays are discussed through practical examples.

Introduction. In modern programming systems, efficient storage and processing of data play a crucial role. For this reason, programming languages offer various data structures. One of the most frequently used data structures in C++ is arrays. Arrays allow storing elements of the same type in an ordered structure, provide direct access through memory addresses, and enable fast processing.

C++ supports different types of arrays that simplify working with matrices, vectors, tables, multi-dimensional models, and other complex data structures. This article deeply analyzes the types of arrays, their structure, unique features, and practical usage.

Literature Review. Scientific research on C++ arrays covers various areas, including:

Bjarne Stroustrup – in "The C++ Programming Language," describes low-level memory management and efficiency advantages of arrays in detail.

Herbert Schildt – in "C++: The Complete Reference," systematically explains static and dynamic arrays and functions used with them.

Nicolai Josuttis – in "The C++ Standard Library," analyzes STL containers such as vector, array, and deque as alternatives to arrays.

Scientific articles frequently discuss efficiency analysis, indexing time complexity, cache optimization, and dynamic memory management related to arrays.

These sources strengthen theoretical and practical knowledge of using arrays in C++.

Main Part

1. The concept of arrays and their role in C++

An array is an ordered collection of elements of the same type, indexed sequentially. A key feature of C++ arrays is their fixed size and contiguous memory placement.

Syntax:

```
int a[5] = {1, 2, 3, 4, 5};
```

2. One-dimensional arrays

These are the simplest form of arrays and are used for linear data processing.

Advantages:

– O(1) access via index
– High cache efficiency due to contiguous memory layout

Disadvantages:

– Fixed size (compile-time)
– Cannot be resized dynamically

Example:

```
int a[10];
for (int i = 0; i < 10; i++) {
    a[i] = i * 2;
}
```

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3. Two-dimensional arrays
These are matrix-like structures widely used in tables, graphics, and modeling.

Example:
```
int mat[3][3] = {
    {1,2,3},
    {4,5,6},
    {7,8,9}
};
```
4. Multi-dimensional arrays
C++ allows creating arrays with any number of dimensions:
```
int arr[3][4][5];
```
Commonly used in physics simulations, 3D graphics, and scientific computations.
5. Dynamic arrays (Heap-based arrays)
Due to limitations of static arrays, dynamic arrays are widely used.
Created using the new operator:
```
int* arr = new int[n];
```
Advantages:
– Size may be determined at runtime
Disadvantages:
– Requires manual memory management (delete)
– Higher chance of runtime errors
6. Comparison of STL containers and arrays

Structure	Size	Flexibility	Speed	Memory
Static array	Fixed	Low	Very high	Most efficient
Dynamic array	Variable	Medium	High	Manually managed
std::vector	Dynamic	Very high	High	Automatic
std::array	Fixed	Medium	Very high	Efficient

7. Algorithmic analysis of arrays
– Searching: Linear search — O(n)
– Sorting: O(n log n)
– Index access: O(1)
– Cache optimization: high (due to sequential memory placement)
8. Practical applications
– Sensor data storage
– Digital image processing
– Matrix calculations
– Game engines
– Artificial intelligence algorithms (e.g., neural networks)

Conclusion. Arrays in C++ are among the most efficient and fast data structures. They support multi-dimensional formations, handle large amounts of data quickly, and deliver high performance. Each type of array—static, dynamic, and STL-based—has significant advantages depending on usage. Research shows arrays outperform many data structures in efficiency, memory control, and structural organization. Future studies aim to optimize array-related algorithms and create more lightweight data structures.

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