

Fenwick tree

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Fenwick tree (aka **Binary indexed tree**) is a data structure that maintains a sequence of elements, and is able to compute cumulative sum of any range of consecutive elements in $O(\log n)$ time. Changing value of any single element needs $O(\log n)$ time as well.

The structure is space-efficient in the sense that it needs the same amount of storage as just a simple array of n elements.

Sample C++ Implementation

```
#include <vector>
using namespace std;

// In this implementation, the tree is represented by a vector<int>.
// Elements are numbered by 0, 1, ..., n-1.
// tree[i] is sum of elements with indexes i&(i+1)..i, inclusive.
// (Note: this is a bit different from what is proposed in Fenwick's article.
// To see why it makes sense, think about the trailing 1's in binary
// representation of indexes.)

class Fenwick_Tree_Sum
{
    vector<int> tree;
    Fenwick_Tree_Sum(const vector<int>& Arg) //Arg is our array on which we are going to work
    {
        tree.resize(Arg.size());

        for(int i = 0 ; i<tree.size(); i++)
            increase(i, Arg[i]);
    }

    // Increases value of i-th element by 'delta'.
    void increase(int i, int delta)
    {
        for (; i < (int)tree.size(); i |= i + 1)
            tree[i] += delta;
    }

    // Returns sum of elements with indexes left..right, inclusive; (zero-based);
    int getsum(int left, int right)
    {
        return sum(right) - sum(left-1); //when left equals 0 the function hopefully returns 0
    }

    int sum(int ind)
    {
        int sum = 0;
        while (ind>=0)
        {
            sum += tree[ind];
            ind &= ind + 1;
            ind--;
        }
        return sum;
    }
}
```

};

References

- Peter M. Fenwick. A new data structure for cumulative frequency tables (<http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.14.8917>) . Software - Practice and Experience, 24(3):327--336, March 1994.
- <http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=binaryIndexedTrees>
- http://en.wikipedia.org/wiki/Fenwick_tree

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