Notebook - Maratona de Programação

Cabo HDMI, VGA, USB

Contents

1 String

1.1 String hash

Complexity: O(n) preprocessing, O(1) query
Computes the hash of arbitrary substrings of a given string s.

```
// TITLE: String hash
// COMPLEXITY: O(n) preprocessing, O(1) query
// DESCRIPTION: Computes the hash of arbitrary substrings of a given string s.

struct hashs
{
    string s;
    int m1, m2, n, p;
    vector<int> p1, p2, sum1, sum2;

    hashs(string s) : s(s), n(s.size()), p1(n + 1), p2(n + 1), sum1(n + 1), sum2(n + 1)
    {
        srand(time(0));
        p = 31;
        m1 = rand() / 10 + 1e9; // 1000253887;
        m2 = rand() / 10 + 1e9; // 1000546873;

        p1[0] = p2[0] = 1;
        loop(i, 1, n + 1)
        {
            p1[i] = (p * p1[i - 1]) % m1;
            p2[i] = (p * p2[i - 1]) % m2;
        }

        sum1[0] = sum2[0] = 0;
        loop(i, 1, n + 1)
        {
            sum1[i] = (sum1[i - 1] * p) % m1 + s[i - 1];
            sum2[i] = (sum2[i - 1] * p) % m2 + s[i - 1];
            sum1[i] %= m1;
            sum2[i] %= m2;
        }
    }

    // hash do intervalo [l, r)
    int gethash(int l, int r)
    {
        int c1 = m1 - (sum1[l] * p1[r - l]) % m1;
        int c2 = m2 - (sum2[l] * p2[r - l]) % m2;
        int h1 = (sum1[r] + c1) % m1;
        int h2 = (sum2[r] + c2) % m2;
        return (h1 << 30) ^ h2;
    }
};
```

1.2 Z function

Complexity: Z function complexity
z function

```
// TITLE: Z function
// COMPLEXITY: Z function complexity
// DESCRIPTION: z function

void z_function(string& s)
{
    return;
}
```

1.3 Suffix Array

Complexity: O(n log(n)), contains big constant (around 25).
Computes the hash of arbitrary substrings of a given string s.

```
// TITLE: Suffix Array
// COMPLEXITY: O(n log(n)), contains big constant (around 25).
// DESCRIPTION: Computes the hash of arbitrary substrings of a given string s.

void countingsort(vi& p, vi& c) {
    int n=p.size();
    vi count(n,0);
    loop(i,0,n) count[c[i]]++;

    vi psum(n); psum[0]=0;
    loop(i,1,n) psum[i]=psum[i-1]+count[i-1];

    vi ans(n);
    loop(i,0,n)
        ans[psum[c[p[i]]]++]=p[i];

    p = ans;
}

vi sfa(string s) {
    s += "$";

    int n=s.size();
    vi p(n);
    vi c(n);
    {
        vector<pair<char, int>> a(n);
        loop(i,0,n) a[i]={s[i],i};
        sort(all(a));

        loop(i,0,n) p[i]=a[i].second;

        c[p[0]]=0;
        loop(i,1,n) {
            if(s[p[i]] == s[p[i-1]]) {
                c[p[i]]=c[p[i-1]];
            }
            else c[p[i]]=c[p[i-1]]+1;
        }
    }

    for(int k=0; (1<<k) < n; k++) {
        loop(i, 0, n)
            p[i] = (p[i] - (1<<k) + n) % n;

        countingsort(p,c);

        vi nc(n);
        nc[p[0]]=0;
        loop(i,1,n) {
            pii prev = {c[p[i-1]], c[(p[i-1]+(1<<k))%n]};
            pii cur = {c[p[i]], c[(p[i]+(1<<k))%n]};

            if (prev == cur)
                nc[p[i]]=nc[p[i-1]];
            else nc[p[i]]=nc[p[i-1]]+1;
        }
        c=nc;
    }

    return p;
}
```

2 Segtree

2.1 Standard SegTree

Complexity: O(log(n)) query and update
Sum segment tree with point update.

```
// TITLE: Standard SegTree
// COMPLEXITY: O(log(n)) query and update
// DESCRIPTION: Sum segment tree with point update.

using type = int;

type iden = 0;
vector<type> seg;
int segsize;

type func(type a, type b)
{
    return a + b;
}

// query do intervalo [l, r)
type query(int l, int r, int no = 0, int lx = 0, int rx = segsize)
{
    // l lx rx r
    if (r <= lx or rx <= l)
        return iden;
    if (l <= lx and rx <= r)
        return seg[no];

    int mid = lx + (rx - lx) / 2;
    return func(query(l, r, 2 * no + 1, lx, mid),
                query(l, r, 2 * no + 2, mid, rx));
}

void update(int dest, type val, int no = 0, int lx = 0, int rx = segsize)
{
    if (dest < lx or dest >= rx)
        return;
    if (rx - lx == 1)
    {
        seg[no] = val;
        return;
    }

    int mid = lx + (rx - lx) / 2;
    update(dest, val, 2 * no + 1, lx, mid);
    update(dest, val, 2 * no + 2, mid, rx);
    seg[no] = func(seg[2 * no + 1], seg[2 * no + 2]);
}

signed main()
{
    ios_base::sync_with_stdio(0);
    cin.tie(0);
    cout.tie(0);
    int n;
    cin >> n;
    segsize = n;
    if (__builtin_popcount(n) != 1)
    {
        segsize = 1 + (int)log2(segsize);
        segsize = 1 << segsize;
    }
    seg.assign(2 * segsize - 1, iden);

    loop(i, 0, n)
    {
        int x;
        cin >> x;
        update(i, x);
    }
}
```

2.2 Lazy SegTree

Complexity: O(log(n)) query and update
Sum segment tree with range sum update.

```
// TITLE: Lazy SegTree
// COMPLEXITY: O(log(n)) query and update
// DESCRIPTION: Sum segment tree with range sum update.
vector<int> seg, lazy;
int segsize;

// change 0s to -1s if update is
// set instead of add. also,
// remove the +=s
void prop(int no, int lx, int rx) {
    if (lazy[no] == 0) return;

    seg[no]+=(rx-lx)*lazy[no];
    if(rx-lx>1) {
        lazy[2*no+1] += lazy[no];
        lazy[2*no+2] += lazy[no];
    }

    lazy[no]=0;
}

void update(int l, int r, int val,int no=0, int lx=0, int rx=segsize) {
    // l r lx rx
    prop(no, lx, rx);
    if (r <= lx or rx <= l) return;
    if (l <= lx and rx <= r) {
        lazy[no]=val;
        prop(no,lx,rx);
        return;
    }

    int mid=lx+(rx-lx)/2;
    update(l,r,val,2*no+1,lx,mid);
    update(l,r,val,2*no+2,mid,rx);
    seg[no] =seg[2*no+1]+seg[2*no+2];
}

int query(int l,int r,int no=0,int lx=0, int rx=segsize) {
    prop(no,lx,rx);
    if (r <= lx or rx <= l) return 0;
    if (l <= lx and rx <= r) return seg[no];

    int mid=lx+(rx-lx)/2;
    return query(l,r,2*no+1, lx, mid)+
           query(l,r,2*no+2,mid,rx);
}

signed main() {
    ios_base::sync_with_stdio(0);cin.tie(0);cout.tie(0);

    int n;cin>>n;
    segsize=n;
    if(__builtin_popcount(n) != 1) {
        segsize=1+(int)log2(segsize);
        segsize= 1<<segsize;
    }

    seg.assign(2*segsize-1, 0);
    // use -1 instead of 0 if
```

```
    // update is set instead of add
    lazy.assign(2*segsize-1, 0);
}
```

3 Set

3.1 Ordered Set

Complexity: O(log(n))

```
// TITLE: Ordered Set
// COMPLEXITY: O(log(n))
// DESCRIPION: Set but you can look witch elements is in position (k)

#include <ext/pb_ds/assoc_container.hpp>
#include <ext/pb_ds/tree_policy.hpp>
using namespace __gnu_pbds;

#define ordered_set tree<int, null_type,less<int>, rb_tree_tag,tree_order_statistics_node_update>

int32_t main() {
    ordered_set o_set;

    o_set.insert(5);
    o_set.insert(1);
    o_set.insert(2);
    // o_set = {1, 2, 5}
    5 == *(o_set.find_by_order(2));
    2 == o_set.order_of_key(4); // {1, 2}
}
```

3.2 Multiset

Complexity: O(log(n))
Same as set but you can have multiple elements with same values

```
// TITLE: Multiset
// COMPLEXITY: O(log(n))
// DESCRIPTION: Same as set but you can have multiple elements with same values

int main() {
  multiset<int> set1;
}
```

3.3 Set

Complexity: Insertion Log(n)
Keeps elements sorted, remove duplicates, upper_bound, lower_bound, find, count

```
// TITLE: Set
// COMPLEXITY: Insertion Log(n)
// Description: Keeps elements sorted, remove duplicates, upper_bound, lower_bound, find, count

int main() {
  set<int> set1;

  set1.insert(1);        // O(log(n))
  set1.erase(1);         // O(log(n))

  set1.upper_bound(1);  // O(log(n))
  set1.lower_bound(1);  // O(log(n))
  set1.find(1);         // O(log(n))
  set1.count(1);        // O(log(n))

  set1.size();          // O(1)
  set1.empty();         // O(1)

  set1.clear()          // O(1)
  return 0;
}
```

4 Graph

4.1 Topological Sort

Complexity: O(N + M), N: Vertices, M: Arestas
Retorna no do grapho em ordem topologica, se a quantidade de nos retornada nao for igual a quantidade de nos e impossivel

```
// TITLE: Topological Sort
// COMPLEXITY: O(N + M), N: Vertices, M: Arestas
// DESCRIPTION: Retorna no do grapho em ordem topologica, se a quantidade de nos retornada nao for igual a quantidade de nos e impossivel

typedef vector<vector<int>> Adj_List;
typedef vector<int> Indegree_List; // How many nodes depend on him
typedef vector<int> Order_List;    // The order in which the nodes appears

Order_List kahn(Adj_List adj, Indegree_List indegree)
{
    queue<int> q;
    // priority_queue<int> q; // If you want in lexicografic order
    for (int i = 0; i < indegree.size(); i++) {
        if (indegree[i] == 0)
            q.push(i);
    }
    vector<int> order;

    while (not q.empty()) {
        auto a = q.front();
        q.pop();

        order.push_back(a);
        for (auto b: adj[a]) {
            indegree[b]--;
            if (indegree[b] == 0)
                q.push(b);
        }
    }
    return order;
}

int32_t main()
{

    Order_List = kahn(adj, indegree);
    if (Order_List.size() != N) {
        cout << "IMPOSSIBLE" << endl;
    }
    return 0;
}
```

4.2 Kth Ancestor

Complexity: O(n * log(n))
Preprocess, then find in log n

```cpp
// TITLE: Kth Ancestor
// COMPLEXITY: O(n * log(n))
// DESCRIPTION: Preprocess, then find in log n

const int LOG_N = 30;
int get_kth_ancestor(vector<vector<int>> & up, int v, int k)
{
    for (int j = 0; j < LOG_N; j++) {
        if (k & ((int)1 << j)) {
            v = up[v][j];
        }
    }
    return v;
}

void solve()
{
    vector<vector<int>> up(n, vector<int>(LOG_N));

    for (int i = 0; i < n; i++) {
        up[i][0] = parents[i];
        for (int j = 1; j < LOG_N; j++) {
            up[i][j] = up[up[i][j-1]][j-1];
        }
    }
    cout << get_kth_ancestor(up, x, k) << endl;

}
```

4.3 Dinic

Complexity: O(V*V*E), Bipartite is O(sqrt(V) E)
Dinic is a strongly polynomial maximum flow algorithm, doesnt depend on capacity values good for matching

```cpp
// TITLE: Dinic
// COMPLEXITY: O(V*V*E), Bipartite is O(sqrt(V) E)
// DESCRIPTION: Dinic is a strongly polynomial maximum flow algorithm, doesnt depend on capacity values good for matching

const int oo = 0x3f3f3f3f3f3f3f3f;
// Edge structure
struct Edge
{
    int from, to;
    int flow, capacity;

    Edge(int from_, int to_, int flow_, int capacity_)
        : from(from_), to(to_), flow(flow_), capacity(capacity_)
    {}
};

struct Dinic
{
    vector<vector<int>> graph;
    vector<Edge> edges;
    vector<int> level;
    int size;

    Dinic(int n)
    {
        graph.resize(n);
        level.resize(n);
        size = n;
        edges.clear();
    }

    void add_edge(int from, int to, int capacity)
    {
        edges.emplace_back(from, to, 0, capacity);
        graph[from].push_back(edges.size() - 1);

        edges.emplace_back(to, from, 0, 0);
        graph[to].push_back(edges.size() - 1);
    }

    int get_max_flow(int source, int sink)
    {
        int max_flow = 0;
        vector<int> next(size);
        while(bfs(source, sink)) {
            next.assign(size, 0);
            for (int f = dfs(source, sink, next, oo); f != 0; f = dfs(source, sink, next, oo)) {
                max_flow += f;
            }
        }
        return max_flow;
    }

    bool bfs(int source, int sink)
    {
        level.assign(size, -1);
        queue<int> q;
        q.push(source);
        level[source] = 0;

        while(!q.empty()) {
            int a = q.front();
            q.pop();

            for (int & b: graph[a]) {
                auto edge = edges[b];
                int cap = edge.capacity - edge.flow;
                if (cap > 0 && level[edge.to] == -1) {
                    level[edge.to] = level[a] + 1;
                    q.push(edge.to);
                }
            }
        }
        return level[sink] != -1;
    }

    int dfs(int curr, int sink, vector<int> & next, int flow)
    {
        if (curr == sink) return flow;
        int num_edges = graph[curr].size();

        for (; next[curr] < num_edges; next[curr]++) {
            int b = graph[curr][next[curr]];
            auto & edge = edges[b];
            auto & rev_edge = edges[b^1];

            int cap = edge.capacity - edge.flow;
            if (cap > 0 && (level[curr] + 1 == level[edge.to])) {
                int bottle_neck = dfs(edge.to, sink, next, min(flow, cap));
                if (bottle_neck > 0) {
                    edge.flow += bottle_neck;
                    rev_edge.flow -= bottle_neck;
                    return bottle_neck;
```

```
                }
            }
        }
        return 0;
    }
};

// Example on how to use
void solve()
{
    int n, m;
    cin >> n >> m;
    int N = n + m + 2;

    int source = N - 2;
    int sink = N - 1;

    Dinic flow(N);

    for (int i = 0; i < n; i++) {
        int q; cin >> q;
        while(q--) {
            int b; cin >> b;
            flow.add_edge(i, n + b - 1, 1);
        }
    }
    for (int i =0; i < n; i++) {
        flow.add_edge(source, i, 1);
    }
    for (int i =0; i < m; i++) {
        flow.add_edge(i + n, sink, 1);
    }

    cout << m - flow.get_max_flow(source, sink) <<
    endl;

    // Getting participant edges
    for (auto & edge: flow.edges) {
        if (edge.capacity == 0) continue; // This
    means is a reverse edge
        if (edge.from == source || edge.to == source)
     continue;
        if (edge.from == sink   || edge.to == sink)
    continue;
        if (edge.flow == 0) continue; // Is not
    participant

        cout << edge.from + 1 << " " << edge.to -n +
    1 << endl;
    }
}
```

4.4 Bellman Ford

Complexity: O(n * m) | n = |nodes|, m = |edges|
Finds shortest paths from a starting node to all nodes of the graph. The node can have negative cycle and belman-ford will detected

```
// TITLE: Bellman Ford
// COMPLEXITY: O(n * m) | n = |nodes|, m = |edges|
// DESCRIPTION: Finds shortest paths from a starting
     node to all nodes of the graph. The node can have
      negative cycle and belman-ford will detected

// a and b vertices, c cost
// [{a, b, c}, {a, b, c}]
vector<tuple<int, int, int>> edges;
int N;

void bellman_ford(int x){
    for (int i = 0; i < N; i++){
        dist[i] = oo;
    }
    dist[x] = 0;

    for (int i = 0; i < N - 1; i++){
        for (auto [a, b, c]: edges){
            if (dist[a] == oo) continue;
            dist[b]= min(dist[b], dist[a] + w);
        }
    }
}
// return true if has cycle
bool check_negative_cycle(int x){
    for (int i = 0; i < N; i++){
        dist[i] = oo;
    }
    dist[x] = 0;

    for (int i = 0; i < N - 1; i++){
        for (auto [a, b, c]: edges){
            if (dist[a] == oo) continue;
            dist[b]= min(dist[b], dist[a] + w);
        }
    }

    for (auto [a, b, c]: edges){
        if (dist[a] == oo) continue;
        if (dist[a] + w < dist[b]){
            return true;
        };
    }
    return false;
}
```

5 Parser

5.1 Parsing Functions

Complexity:

```
// TITLE: Parsing Functions

vector<string> split_string(const string & s, const
    string & sep = " ") {
    int w = sep.size();
    vector<string> ans;
    string curr;

    auto add = [&](string a) {
        if (a.size() > 0) {
            ans.push_back(a);
        }
    };

    for (int i = 0; i + w < s.size(); i++) {
        if (s.substr(i, w) == sep) {
            i += w-1;
            add(curr);
            curr.clear();
            continue;
        }
        curr.push_back(s[i]);
    }
    add(curr);
    return ans;
}
```

```cpp
vector<int> parse_vector_int(string & s)
{
    vector<int> nums;
    for (string x: split_string(s)) {
        nums.push_back(stoi(x));
    }
    return nums;
}

vector<float> parse_vector_float(string & s)
{
    vector<float> nums;
    for (string x: split_string(s)) {
        nums.push_back(stof(x));
    }
    return nums;
}

void solve()
{
    cin.ignore();
    string s;
    getline(cin, s);

    auto nums = parse_vector_float(s);
    for (auto x: nums) {
        cout << x << endl;
    }
}
```