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BCSE UG III (Sem II)

AI Lab Assignment 2

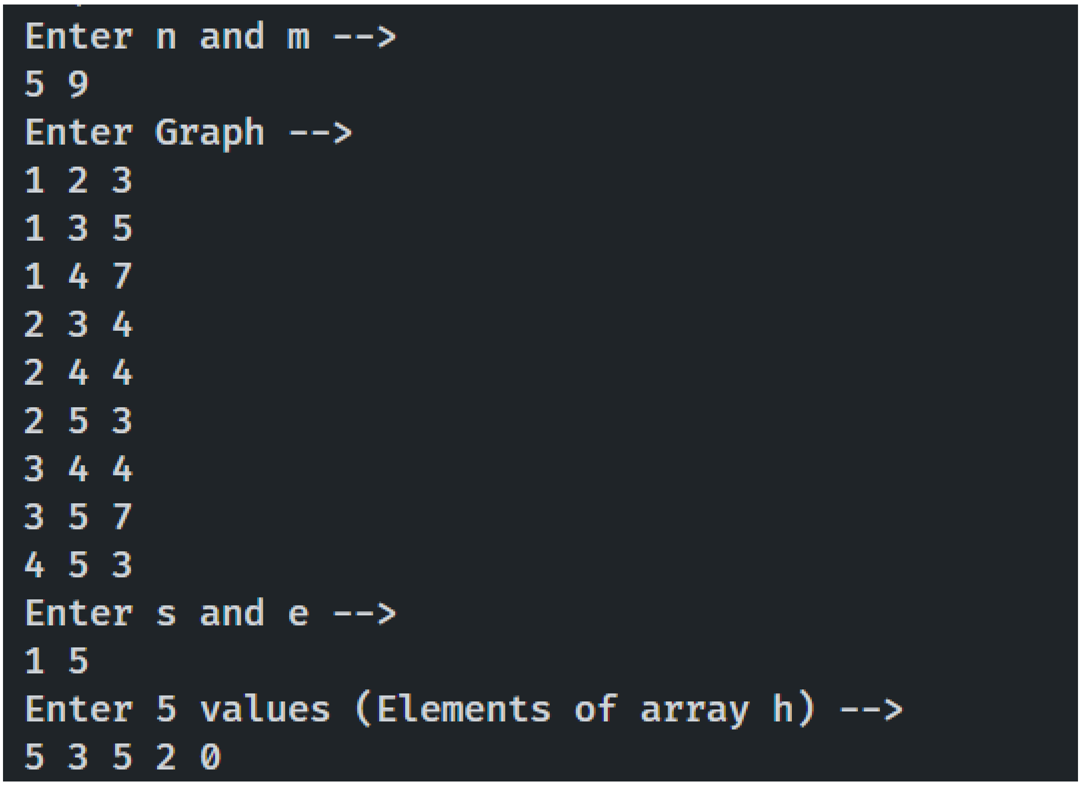
Question 2

2. Implement the following :
    - Best first greedy search
    - A* search algorithm

Solution

```
#include <iostream>
#include <vector>
#include <queue>
#include <algorithm>
#include <utility>
#include <set>
#define INF 1e9+7

using namespace std;

struct answer
{
    vector <int> order;
    vector <int> path;
};

answer bfs(int s, int e, vector <pair<int,int>> adj[], int h[], int n)
{
    int p[n+1];
    for(int i=1;i<=n;i++)
    p[i]=-1;

    answer ret;

    vector <bool> marked(n+1,false);
    set <pair<int,int>> st; // dist, vertex
    st.insert({h[s],s});

    marked[s]=true;

    while(true)
    {
        auto v=*st.begin();
        ret.order.push_back(v.second);

        st.erase(v);

        if(v.second==e)
        break;

        for(auto u:adj[v.second])
        if(!marked[u.first])
        {
            st.insert({h[u.first],u.first});
            p[u.first]=v.second;
            marked[u.first]=true;
        }
    }

    int curr=e;
    while(curr!=-1)
    {
        ret.path.push_back(curr);
        curr=p[curr];
    }

    reverse(ret.path.begin(),ret.path.end());

    return ret;
}

answer astar(int s, int e, vector <pair<int,int>> adj[], int h[], int n)
{
    set <pair<int,int>> st;
    vector <int> d(n+1,INF);
    vector <int> p(n+1,-1);
    d[s]=h[s];

    answer ret;
    st.insert({h[s],s});

    while(true)
    {
        auto v=*st.begin();
        ret.order.push_back(v.second);

        st.erase(v);

        if(v.second==e)
        break;

        for(auto u:adj[v.second])
        if(d[u.first]>d[v.second]-h[v.second]+h[u.first]+u.second)
        {
            st.erase({d[u.first],u.first});
            d[u.first]=d[v.second]-h[v.second]+h[u.first]+u.second;
            st.insert({d[u.first],u.first});
            p[u.first]=v.second;
        }
    }

    int curr=e;
    while(curr!=-1)
    {
        ret.path.push_back(curr);
        curr=p[curr];
    }

    reverse(ret.path.begin(),ret.path.end());

    return ret;
}

signed main()
{
    freopen("input.in","r",stdin);

    int n,m;
    cin>>n>>m;

    vector <pair<int,int>> adj[n+1];
    int h[n+1];

    for(int i=1;i<=m;++i)
    {
        int a,b,c;
        cin>>a>>b>>c;
        adj[a].push_back({b,c});
        adj[b].push_back({a,c});
    }

    int s,e;
    cin>>s>>e;

    for(int i=1;i<=n;i++)
    cin>>h[i];

    answer out=astar(s,e,adj,h,n);

    cout<<"ORDER"<<endl;
    for(auto x:out.order)
    cout<<x<<" ";
    cout<<endl<<"PATH"<<endl;
    for(auto x:out.path)
    cout<<x<<" ";
    cout<<endl;

    return 0;
}
```

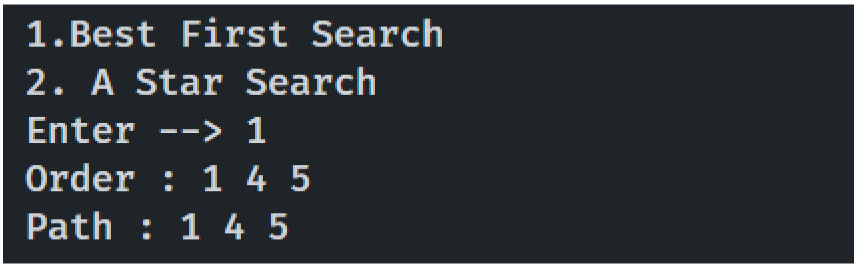
Input



```
Enter n and m -->
5 9
Enter Graph -->
1 2 3
1 3 5
1 4 7
2 3 4
2 4 4
2 5 3
3 4 4
3 5 7
4 5 3
Enter s and e -->
1 5
Enter 5 values (Elements of array h) -->
5 3 5 2 0
```

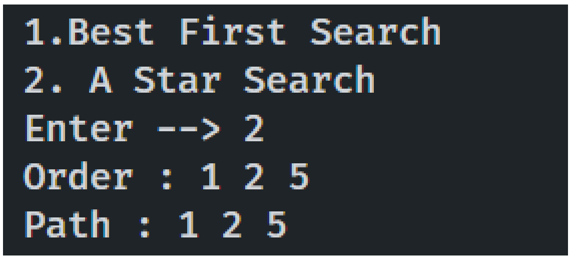
Ouput

- Best First Search



```
1.Best First Search
2. A Star Search
Enter --> 1
Order : 1 4 5
Path : 1 4 5
```

- A*



```
1.Best First Search
2. A Star Search
Enter --> 2
Order : 1 2 5
Path : 1 2 5
```

Uniform Cost Search (UCS)

```
// C++ implementation of above approach
#include <bits/stdc++.h>
using namespace std;
```

```cpp
// graph
vector<vector<int>> graph;

// map to store cost of edges
map<pair<int, int>, int> cost;

// returns the minimum cost in a vector( if there are multiple goal states)
vector<int> uniform_cost_search(vector<int> goal, int start) {

    // minimum cost upto goal state from starting state
    vector<int> answer;

    // create a priority queue
    priority_queue<pair<int, int> > queue;

    // set the answer vector to max value
    for (int i = 0; i < goal.size(); i++) answer.push_back(INT_MAX);

    // insert the starting index
    queue.push(make_pair(0, start));

    // map to store visited node
    map<int, int> visited;

    // count
    int count = 0;

    // while the queue is not empty
    while (queue.size() > 0) {
        // get the top element of the
        // priority queue
        pair<int, int> p = queue.top();

        // pop the element
        queue.pop();

        // get the original value
        p.first *= -1;

        // check if the element is part of
        // the goal list
        if (find(goal.begin(), goal.end(), p.second) != goal.end()) {
            // get the position
            int index = find(goal.begin(), goal.end(), p.second) - goal.begin();

            // if a new goal is reached
            if (answer[index] == INT_MAX) count++;

            // if the cost is less
            if (answer[index] > p.first) answer[index] = p.first;

            // pop the element
            queue.pop();
            // if all goals are reached
            if (count == goal.size()) return answer;
        }

        // check for the non visited nodes
        // which are adjacent to present node
        if (visited[p.second] == 0) {
            for (int i = 0; i < graph[p.second].size(); i++) {
                // value is multiplied by -1 so that
                // least priority is at the top
                queue.push(make_pair(
                    (p.first + cost[make_pair(p.second, graph[p.second][i])]) *
-1,
                    graph[p.second][i]));
            }
        }

        // mark as visited
        visited[p.second] = 1;
    }

    return answer;
}

// main function
int main() {
    // create the graph
    graph.resize(7);

    // add edge
    graph[0].push_back(1);
    graph[0].push_back(3);
    graph[3].push_back(1);
    graph[3].push_back(6);
    graph[3].push_back(4);
    graph[1].push_back(6);
    graph[4].push_back(2);
    graph[4].push_back(5);
    graph[2].push_back(1);
    graph[5].push_back(2);
    graph[5].push_back(6);
    graph[6].push_back(4);

    // add the cost
    cost[make_pair(0, 1)] = 2;
    cost[make_pair(0, 3)] = 5;
    cost[make_pair(1, 6)] = 1;
    cost[make_pair(3, 1)] = 5;
    cost[make_pair(3, 6)] = 6;
    cost[make_pair(3, 4)] = 2;
    cost[make_pair(2, 1)] = 4;
    cost[make_pair(4, 2)] = 4;
    cost[make_pair(4, 5)] = 3;
    cost[make_pair(5, 2)] = 6;
    cost[make_pair(5, 6)] = 3;
    cost[make_pair(6, 4)] = 7;

    // goal state
    vector<int> goal;

    // set the goal
    // there can be multiple goal states
    goal.push_back(6);

    // get the answer
    vector<int> answer = uniform_cost_search(goal, 0);

    // print the answer
    cout << "Minimum cost from 0 to 6 is = " << answer[0] << endl;

    return 0;
}
```