School of Data and Computer Science, Sun Yat-sen University

The Water Jug Riddle

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1 Problem Description

This is a problem that is prominently featured in the film Die Hard With a Vengeance. You have a 3-gallon and a 5-gallon jug that you can fill from a fountain of water. The problem is to fill one of the jugs with exactly 4 gallons of water. How do you do it?

This is the solution (not the only solution):

1. Fill up the 3-gallon jug
2. Transfer to the 5-gallon jug
3. Fill up the 3-gallon jug again
4. Transfer water to fill up the 5-gallon jug, leaving 1 gallon in the 3-gallon jug
5. Empty out the 5-gallon jug
6. Transfer the 1 gallon to the 5-gallon jug
7. Fill up the 3-gallon jug and transfer that to the 5-gallon jug
8. The 5-gallon jug contains 4 gallons of water

The sequence here is:

$(0,3)->(3,0)->(3,3)->(5,1)->(0,1)->(1,0)->(1,3)->(4,0)$

2 Task

1. Please solve the Water Jug Riddle by using A* search algorithm.
2. The reference code can be found in ReferenceWaterJub.rar, which you can use to accomplish this task by adding your A* heuristic function.
3. Don't forget to run at least 3 instances to verify the correctness of your programs.
4. Write the related codes and take a screenshot of the running results in the file named E03_YourNumber.pdf, and send it to ai_2017@formail.com

3 codes

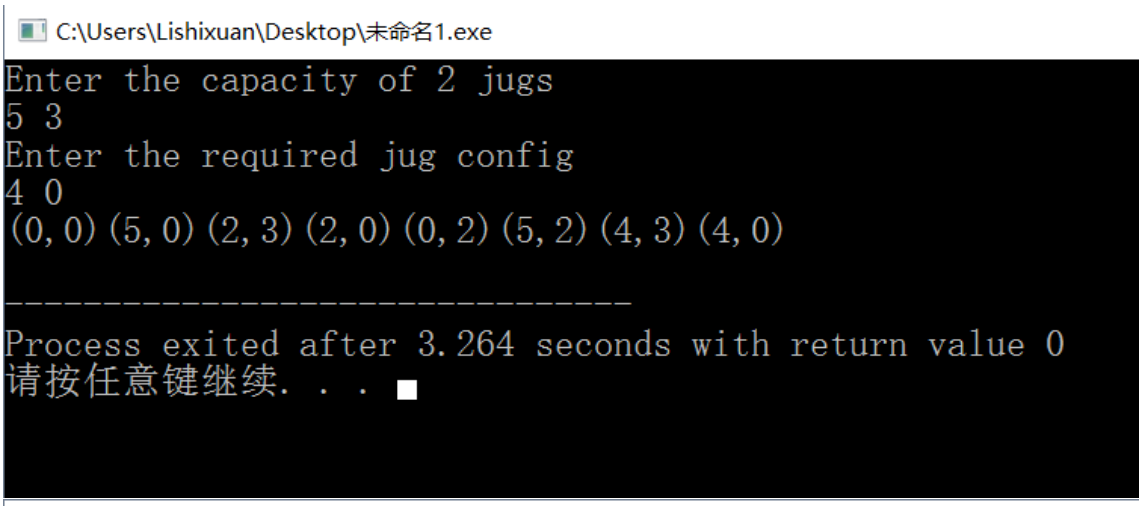
```
#include <bits/stdc++.h>
#include <cmath>
#include <queue>
using namespace std;
class nodes{
        public:
                pair<int,int> p;
                int fval;
                int depth;
                string s;
                bool operator<(const nodes &s) const{
                        return fval > s.fval;
                }
                bool operator>(const nodes &s)const{
                        return fval < s.fval;
                }
                bool operator==(const nodes &s)const{
                        return fval == s.fval;
```

```
                }
};

string makestring(int a,int b){
        std::stringstream out1;
        std::stringstream out2;
        string t1,t2,str;
    out1 << a;
    t1 = out1.str();
    out2 << b;
    t2 = out2.str();
    str = "("+t1+","+t2+")";
    return str;
}

int gcd(int x, int y){
        return y == 0? x: gcd(y, x % y);
}

bool soluble(int fir, int sec, int tar){
        return tar == 0 || (fir + sec > tar && tar % gcd(fir, sec) == 0)
            ;
}

int getf(nodes temp, int s, int e){
        int g = abs(temp.p.first - s) + abs(temp.p.second - e);
        int h = temp.depth;
        return g + h;
}

int main()
{
        //int counter = 0;
    ios::sync_with_stdio(false);
    //pair<int,int> cap,ini,final;
    nodes cap,ini,final;
    ini.p.first=0,ini.p.second=0,ini.fval=0,ini.depth=0;
    ini.s = makestring(ini.p.first,ini.p.second);
    //Input initial values
    cout<<"Enter the capacity of 2 jugs\n";
    cin>>cap.p.first>>cap.p.second;
    //input final values
    cout<<"Enter the required jug config\n";
    cin>> final.p.first >>final.p.second;
    bool sol;
    sol = soluble(cap.p.first, cap.p.second, final.p.first);
    if(sol == 0){
        cout << "No Solution.\n" ;
        return 0;
```

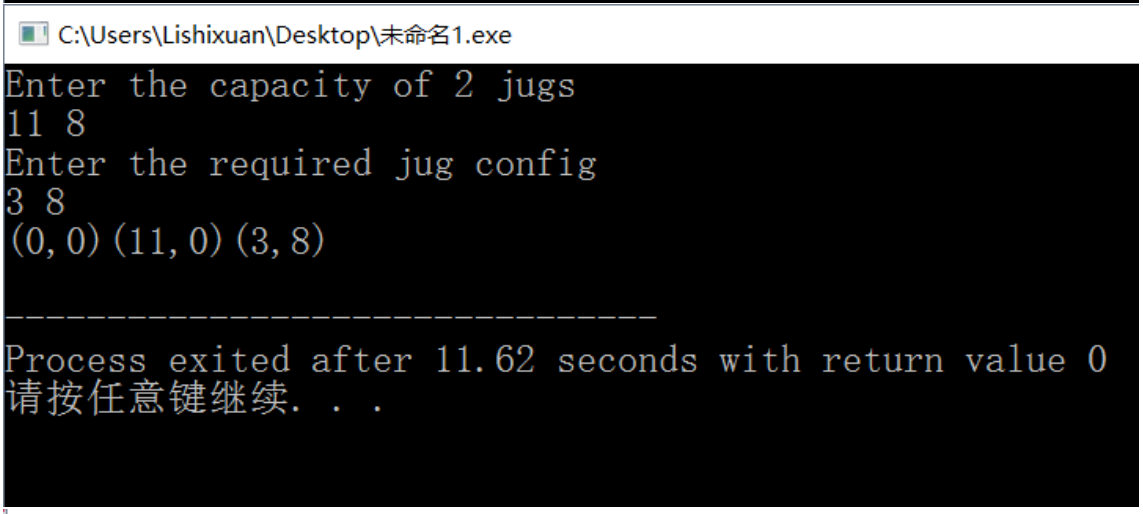
```
}
//Using A* to find the answer
priority_queue<nodes> open;
queue<nodes> close;
open.push(ini);
nodes jug;
while(!open.empty()){
    jug = open.top();
    open.pop();
    close.push(jug);
    if(jug.p.first == final.p.first && jug.p.second == final.p.
       second){
            cout<<jug.s<<endl;
                    break;
    }
    nodes temp = jug;
    //Fill 1st Jug
    if(jug.p.first<cap.p.first){
                    temp.p = make_pair(cap.p.first ,jug.p.second);
                    temp.s = jug.s + makestring(temp.p.first ,temp.p.
                       second);
                    temp.depth = jug.depth + 1;
                    temp.fval = getf(temp, final.p.first , final.p.
                       second);
                    open.push(temp);
    }
    //Fill 2nd Jug
    if(jug.p.second<cap.p.second){
                    temp.p = make_pair(jug.p.first ,cap.p.second);
                    temp.s = jug.s + makestring(temp.p.first ,temp.p.
                       second);
                    temp.depth = jug.depth + 1;
                    temp.fval = getf(temp, final.p.first , final.p.
                       second);
                    open.push(temp);
    }
    //Empty 1st Jug
    if(jug.p.first>0){
                    temp.p = make_pair(0,jug.p.second);
                    temp.s = jug.s + makestring(temp.p.first ,temp.p.
                       second);
                    temp.depth = jug.depth + 1;
                    temp.fval = getf(temp, final.p.first , final.p.
                       second);
                    open.push(temp);
    }
    //Empty 2nd Jug
    if(jug.p.second>0){
                    temp.p = make_pair(jug.p.first ,0);
```

```
                temp.s = jug.s + makestring(temp.p.first ,temp.p.
                    second);
                temp.depth = jug.depth + 1;
                temp.fval = getf(temp, final.p.first , final.p.
                    second);
                open.push(temp);
        }
        //Pour from 1st jug to 2nd until its full
        if(jug.p.first>0 && (jug.p.first+jug.p.second)>=cap.p.second){
                temp.p = make_pair((jug.p.first -(cap.p.second-jug.p.
                    second)),cap.p.second);
                temp.s = jug.s + makestring(temp.p.first ,temp.p.second);
                temp.depth = jug.depth + 1;
                temp.fval = getf(temp, final.p.first , final.p.
                    second);
                open.push(temp);
        }
        //Pour from 2nd jug to 1st until its full
        if(jug.p.second>0 && (jug.p.first+jug.p.second)>=cap.p.first){
                temp.p = make_pair(cap.p.first ,(jug.p.second-(cap.p.
                    first-jug.p.first)));
                temp.s = jug.s + makestring(temp.p.first ,temp.p.second);
                temp.depth = jug.depth + 1;
                temp.fval = getf(temp, final.p.first , final.p.
                    second);
                open.push(temp);
        }
        //Pour all water from 1st to 2nd
        if(jug.p.first>0 && (jug.p.first+jug.p.second)<=cap.p.second){
                temp.p = make_pair(0,jug.p.first+jug.p.second);
                temp.s = jug.s + makestring(temp.p.first ,temp.p.second);
                temp.depth = jug.depth + 1;
                temp.fval = getf(temp, final.p.first , final.p.
                    second);
                open.push(temp);
        }
        //Pour from 2nd jug to 1st until its full
        if(jug.p.second>0 && (jug.p.first+jug.p.second)<=cap.p.first){
                temp.p = make_pair(jug.p.first+jug.p.second,0);
                temp.s = jug.s + makestring(temp.p.first ,temp.p.second);
                temp.depth = jug.depth + 1;
                temp.fval = getf(temp, final.p.first , final.p.
                    second);
                open.push(temp);
        }
    }
        return 0;
}
```

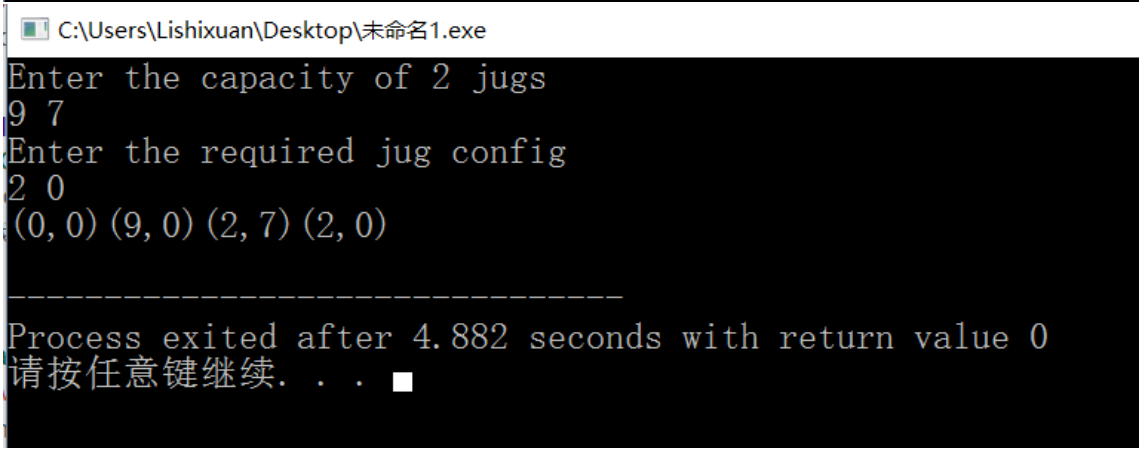
4 Results


C:\Users\Lishixuan\Desktop\未命名1.exe
Enter the capacity of 2 jugs
5 3
Enter the required jug config
4 0
(0,0)(5,0)(2,3)(2,0)(0,2)(5,2)(4,3)(4,0)

Process exited after 3.264 seconds with return value 0
请按任意键继续. . .


C:\Users\Lishixuan\Desktop\未命名1.exe
Enter the capacity of 2 jugs
11 8
Enter the required jug config
3 8
(0,0)(11,0)(3,8)

Process exited after 11.62 seconds with return value 0
请按任意键继续. . .


C:\Users\Lishixuan\Desktop\未命名1.exe
Enter the capacity of 2 jugs
9 7
Enter the required jug config
2 0
(0,0)(9,0)(2,7)(2,0)

Process exited after 4.882 seconds with return value 0
请按任意键继续. . .