Homework 1
Sokoban

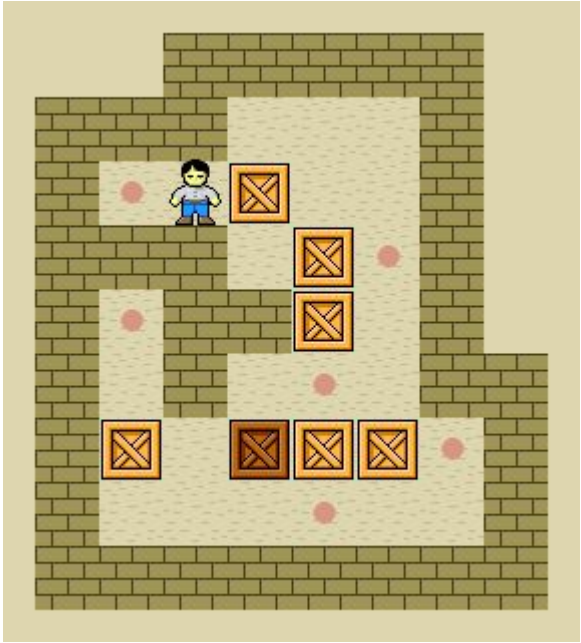
Introduction to Parallel Computing
2022/03/01

https://hackmd.io/@ipc22/hw1

Sokoban

- 倉庫番, sōko-ban

  “a puzzle video game genre in which the player pushes crates or boxes around in a warehouse, trying to get them to storage locations.” - Wikipedia



Goal

- Implement a solver for Sokoban called `hw1.cc`
- Parallelize it with threads
  - `Pthread` or `std::thread`
  - `OpenMP`

Input

- `o`: The player stepping on a regular tile
- `0`: The player stepping on a target tile
- `x`: A box on a regular tile
- `X`: A box on a target tile
- ` `: Nothing on a regular tile
- `.`: Nothing on a target tile
- `#`: Wall
- `@`: A fragile tile
- `!`: The player stepping on a fragile tile

samples/01.txt

```
##########
#  xox..#
#   #####
##########
```

Output

- Print a valid sequence of actions that pushes all the boxes to the target tiles
- Directions: “W”, “A”, “S”, “D”
- e.g. : DDAAASAAWDDDD for 01.txt

```
#########
#  xox..#
#   #####
#########
current action sequence:
solved: False
```

Resources

- /home/ipc22/share/hw1
  - example_solver.py
  - samples
  - play.py
  - validate.py
  - Makefile

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Sample test cases

- 01.txt
- 02.txt
- …
- 20.txt

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Play the game interactively

```
$ /home/ipc22/share/hw1/play.py  \
  /home/ipc22/share/hw1/samples/01.txt
```

```
#########
#  xox..#
#   #####
#########
current action sequence:
solved: False

W/A/S/D to move; U to undo; Q to quit
```

Resources

- /home/ipc22/share/hw1
  - example_solver.py
  - samples
  - play.py
  - validate.py
  - Makefile

Check whether the output is correct

```
$ echo “DDAAASAAWDDDD” | /home/ipc22/share/hw1/validate.py \
  /home/ipc22/share/hw1/samples/01.txt -

Output: OK
```

```
$ srun -c6 -o answer.txt ./hw1 01.txt
$ /home/ipc22/share/hw1/validate.py 01.txt answer.txt
```

Resources

- `/home/ipc22/share/hw1`
  - `example_solver.py`
  - `samples`
  - `play.py`
  - `validate.py`
  - `Makefile`

A simple way to compile your program. Tutorial

Put Makefile and hw1.cc into the same directory

```
$ make hw1    , or
$ make
```

to compile your hw1.cc as hw1

```
$ make clean
```

to remove the executable file

Compile & Execute

Compile

```
$ g++ -std=c++17 -O3 -pthread -fopenmp hw1.cc -o hw1
```

Execute

```
$ ./hw1 /path/to/testcase
```

```
$ srun -n1 -c6 ./hw1 /home/ipc22/share/hw1/samples/01.txt
```

Judge

- Type `hw1-judge` in the directory of hw1.cc
- Scoreboard: https://apollo.cs.nthu.edu.tw/ipc22/scoreboard/hw1/

```
[ipc22t01@apollo31 hw1]$ hw1-judge
Looking for hw1.cc: OK
Looking for Makefile: Not Found
Using fallback: /home/ipc22/share/hw1/Makefile: OK
Running: /usr/bin/make -C /home/ipc22/ipc22t01/.judge.724388966 hw1
make: Entering directory '/home/ipc22/ipc22t01/.judge.724388966'
g++ -std=c++17 -O3 -pthread -fopenmp    hw1.cc    -o hw1
make: Leaving directory '/home/ipc22/ipc22t01/.judge.724388966'
02.txt    0.27   accepted
03.txt    0.27   accepted
01.txt    0.27   accepted
04.txt    0.37   accepted
05.txt    0.27   accepted
07.txt    0.32   accepted
06.txt    0.92   accepted
08.txt    0.42   accepted
09.txt    0.37   accepted
10.txt    0.42   accepted
11.txt    0.47   accepted
12.txt    0.32   accepted
13.txt    0.42   accepted
14.txt    0.32   accepted
15.txt    0.37   accepted
16.txt    0.17   accepted
18.txt    0.32   accepted
17.txt    0.42   accepted
19.txt    0.37   accepted
20.txt    0.32   accepted
21.txt    0.27   accepted
Removing temporary directory /home/ipc22/ipc22t01/.judge.724388966
Scoreboard: not updating {21 6.66} -x-> {21 7.58}
```

Report

Answer the following questions, in either English or Traditional Chinese.

1. Briefly describe your implementation.
2. What are the difficulties encountered in this homework? How did you solve them? (You can discuss about hard-to-optimize hotspots, or synchronization problems)
3. What are the strengths and weaknesses of pthread and OpenMP?
4. (Optional) Any suggestions or feedback for the homework are welcome.

Submission

- Due: Tue, 2022/3/15 23:59
- Submit the following files to EEClass:
  - hw1.cc
  - report.pdf
  - Makefile (optional)
  - ipc22<uid>.txt (optional) (e.g. `ipc22s01.txt`)
    Custom map to be added to hidden test cases. The size of the map should less than 256 pixels.

Hint

OpenMP:

cpucnt: cpus available for the program

Schedule:

- Static (default)
- Dynamic
- Guided

```
#include <omp.h>
#include <thread>
int main() {
    int a[100], b[100], c[100];
    cpu_set_t cpu_set;
    sched_getaffinity(0, sizeof(cpu_set), &cpu_set);
    int cpucnt = CPU_COUNT(&cpu_set);
    #pragma omp parallel for schedule(static) num_threads(cpucnt)
    for (int i = 0; i < 100; i++)
        a[i] = b[i] * c[i];
}
```

Hint

OpenMP:

- Get thread id: `omp_get_thread_num()`
- Critical section: `#pragma omp critical`

```
#include <omp.h>
#include <thread>
#include <cstdio>
int main() {
    int a[100], b[100], c[100];
    int cnt = 0;
    #pragma omp parallel for schedule(static)
    for (int i = 0; i < 100; i++) {
        a[i] = b[i] * c[i];
        int tid = omp_get_thread_num();
        printf("threadID: %d", tid);
        #pragma omp critical
        {
            if (a[i] == 0)
                cnt = cnt + 1;
        }
    }
}
```

Hint

Other test cases:
http://sneezingtiger.com/sokoban/levels.html

Algorithm: BFS, A-star, …
check `/home/ipc22/share/hw1/example_solver.py`

Discuss with your friends!

Plagiarisms are PROHIBITED

Q & A

Feel free to ask if you have any questions.