HW1: Sokoban

1. Briefly (< 100 words) describe your implementation.
   - A star implementation:
     - Heuristic, h(x): the distance between the o and the nearest x + how many x is not on the target tile
     - Only keep h(x) (heuristic), not updating g(x) (the value of the walked path) since path-length is not the priority.
   - Deadlock detection:
     - Mark the corners so that the boxes are not pushed to the corners
     - Patterns such as `xx` and `#x` / `x#` can lead to deadlock
     - Successfully reduce the number of nodes by at least 1/3
   - Data structures:
     - String for state hashing (position of boxes)
     - Set for storing the nodes
     - Linked list for closed nodes (path)
   - Parallel programming (Pthread)
     - Used for the while loop in A-star search

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)
   - Insufficient memory
     - I use a lot of heap. When I implement parallel programming, the compiler keep throwing bad_alloc and segmentation fault error
     - The more the number of thread, the higher the probability of memory leak
     - I have to change a large part of my code in the last minute to save the memory TAT

3. What are the strengths and weaknesses of pthread and OpenMP?

   pthread

   - pthread is lower-level, which the programmers have full control on how and when to create a thread
   - I think pthread work best with shared memory
   - Programmers have to handle the data very carefully

   OpenMP

   - OpenMP is higher-level, which the threads are created by the compiler. The programmer have to specify which part of code can be parallelized
   - Less code to be written to achieve parallelization
   - But is can be confusing when programmers do not understand parallel programming very well

4. Which thread API (pthread or openmp) did you use to implement this homework? Why?
   - I use pthread because I think I can understand parallel computing better by implementing parallel computing to a lower level
   - It is better to figure out things in the first homework.

5. (Optional) Any suggestions or feedback for the homework are welcome.
   - I think sokoban is a challenging and interesting problem to solve. I think it's the only homework which I actually use my brain intensively in these two years. I really need some understanding of algorithm and data structure, etc to solve the problem.
   - By the way, I am still very confused about pthread, especially the memory problem. I currently set the number of threads to 1 to avoid the problem. So I don't think that I did it right actually…