CS 510: Introduction to Artificial Intelligence

Assignment 1

Rush Hour, Part II: Searching for Solutions

In the previous part, we implemented key components of a solver for the puzzle game *Rush Hour*. In this part, we continue with this implementation and significantly extend it to find puzzle solutions using various methods.

Please start with your code from part 1 and extend it as directed below. As before, the code for this part should be written in Python to run on tux.cs.drexel.edu, and we will use the same **run.sh** shell script for testing. Again, **you may only use built-in standard libraries (e.g., math, random, etc.); you may NOT use any external libraries or packages** (if you have any questions at all about what is allowable, please email the instructor).

Paths

Implement a new class, **Path**, that represents a sequence of board states. Add whatever methods are useful for implementing the functionality below, which will likely include **add**() (to add a board to the path), **clone**() (to clone the path for branching), **last**() (to return the last board), and whatever else you need for the rest of the assignment.

Also, please include a path-printing function that prints boards as described in the last part, with one exception: it should print a maximum of 6 boards in a line, and if there are more than 6 boards, it should print the first 6 boards and then continue the rest on a new row of boards (examples below).

Random Walk

Write a method for your **Board** class that does a random walk through next board states. Specifically, given a positive integer *N*=10, the random walk should do the following:

- generate all the moves that can be generated in the board,
- select one at random,
- execute that move,
- and stop if we've reached the goal or we've already executed *N* moves, otherwise repeat.

The function should return the path generated by the random walk, starting with the first given board.

Add a "**random**" command-line command to your code and print the resulting sequence of boards using the print function written for part 1. It should work on a given board or, if there is no board argument, on the default board (see part 1). Here are some examples:

```
> sh run.sh random
------   ------   ------   ------   ------   ------
|  o aa| |  o aa| |  o aa| |  o aa| |  oaa | |  oaaq|
|  o   | |  o   | |  o  q| |  o  q| |  o  q| |  o  q|
|xxo     |xxo     |xxo  q  |xxo  q  |xxo  q  |xxo  q
|ppp  q| | ppp q| | ppp q| |  pppq| |  pppq| |  ppp |
|     q| |     q| |      | |      | |      | |      |
|     q| |     q| |      | |      | |      | |      |
 ------   ------   ------   ------   ------   ------
```

```
 ------    ------    ------    ------
|  oaaq| |  oaaq| |  oaa | |  o aa|
|  o  q| |  o  q| |  o  q| |  o  q|
|xxo  q  |xxo  q  |xxo  q  |xxo  q
| ppp  | |  ppp | |  pppq| |  pppq|
|      | |      | |      | |      |
|      | |      | |      | |      |
 ------    ------    ------    ------
```

```
> sh run.sh random "  oaa |  o   |  o xx|  pppq|     q|     q"
 ------
|  oaa |
|  o   |
|  o xx
|  pppq|
|     q|
|     q|
 ------
```

```
> sh run.sh random "  oaa |  o   |  oxx |  pppq|     q|     q"
------    ------    ------
|  oaa | |  o aa| |  o aa|
|  o   | |  o   | |  o   |
|  oxx   |  oxx   |  o xx
|  pppq| |  pppq| |  pppq|
|     q| |     q| |     q|
|     q| |     q| |     q|
 ------    ------    ------
```

Note that, because this is a random walk, the code will do different things for each run. In the last example, the random walk was lucky in finding the right move to the solution; often, it's not so lucky, and goes all 10 moves without finding the solution.

Breadth-First Search

Write a method for your **Board** class that does a breadth-first search from the given board, returning the first path found that reaches the solution state. Add a "**bfs**" command-line command that allows a user to perform the BFS on a given board, or on the default board (if there is no board argument). The output should print the path being examined at each step. Here is an example:

```
> sh run.sh bfs
------
|  o aa|
|  o   |
|xxo
|ppp  q|
|     q|
|     q|
 ------
 ------    ------
|  o aa| |  oaa |
|  o   | |  o   |
|xxo     |xxo
|ppp  q| |ppp  q|
|     q| |     q|
|     q| |     q|
 ------    ------
```

```
 ------   ------
|  o aa| |  o aa|
|  o   | |  o   |
|xxo     |xxo
|ppp  q| | ppp q|
|     q| |     q|
|     q| |     q|
 ------   ------
 ------   ------
|  o aa| |  o aa|
|  o   | |  o   |
|xxo     |xxo
|ppp  q| |  pppq|
|     q| |     q|
|     q| |     q|
 ------   ------
 ------   ------
|  o aa| |  o aa|
|  o   | |  o   |
|xxo     |xxo  q
|ppp  q| |ppp  q|
|     q| |     q|
|     q| |      |
 ------   ------
```

… and the rest of the paths searched,
ending with the solution and number of paths explored …

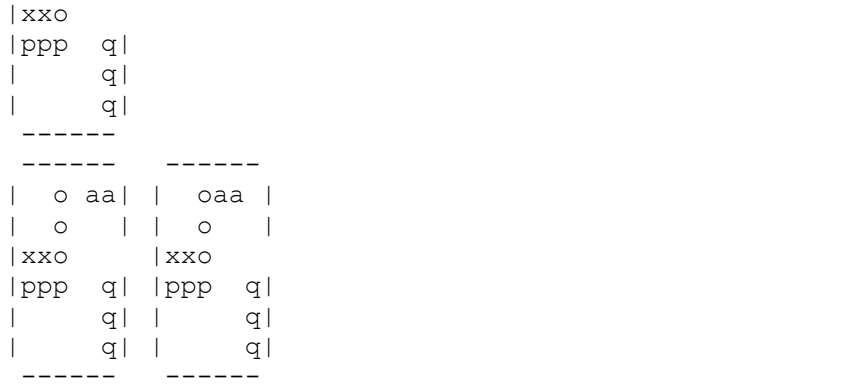
```
------   ------   ------   ------   ------   ------
|  o aa| |  oaa | |  oaaq| |  oaaq| |   aaq| |   aaq|
|  o   | |  o   | |  o  q| |  o  q| |     q| |     q|
|xxo     |xxo     |xxo  q  |xxo  q  |xx   q  |   xxq
|ppp  q| |ppp  q| |ppp   | |   ppp| |  oppp| |  oppp|
|     q| |     q| |      | |      | |  o   | |  o   |
|     q| |     q| |      | |      | |  o   | |  o   |
 ------   ------   ------   ------   ------   ------
 ------   ------   ------   ------
|  oaaq| |  oaaq| |  oaa | |  oaa |
|  o  q| |  o  q| |  o   | |  o   |
|  oxxq  |  oxxq  |  oxx   |  o xx
|   ppp| |  ppp | |  pppq| |  pppq|
|      | |      | |     q| |     q|
|      | |      | |     q| |     q|
 ------   ------   ------   ------
98
```

A Search*

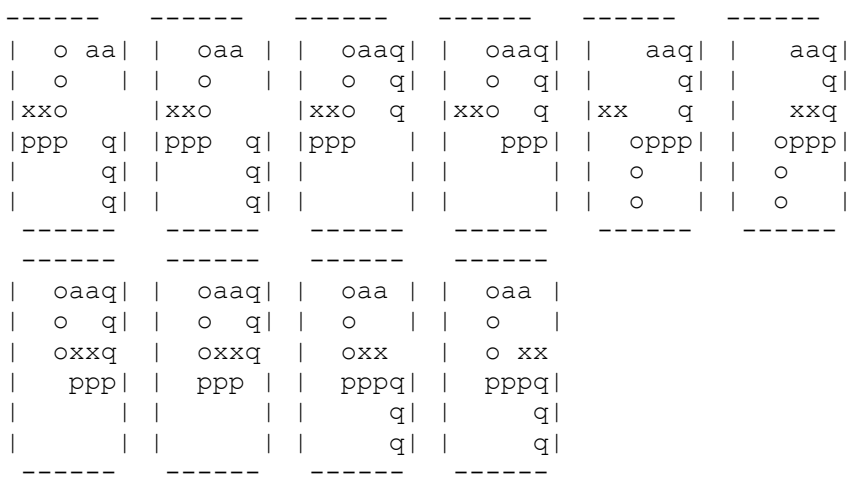
Write a method for your **Board** class that does an A* search from the given board, returning the first path found that reaches the solution state. Note that as part of this process, you will need to choose and implement an *admissible* heuristic function $h(n)$, such that A* can reasonably estimate the minimum cost from a given state to the goal state.

Add an "**astar**" command-line command that allows a user to perform the search on a given board, or on the default board (if there is no board argument). Here is an example:

```
> sh run.sh astar
 ------
|  o aa|
|  o   |
```



... and the rest of the paths searched,
ending with the solution and number of paths explored ...



64

Depending on your chosen heuristic, your number of paths searched may differ from the number in this example, but should be less than the number for BFS.

Academic Honesty

Please remember that you must write all the code for this (and all) assignments by yourself, on your own, without help from anyone except the course TA or instructor.

Submission

Remember that your code must run on **tux.cs.drexel.edu**—that's where we will run the code for testing and grading purposes. Code that doesn't compile or run there will receive a grade of zero.

For this assignment, you must submit:

- Your Python code for this assignment.
- Your **run.sh** shell script that can be run as noted in the examples.

Please use a compression utility to compress your files into a single ZIP file (NOT RAR, nor any other compression format). The final ZIP file must be submitted electronically using Blackboard—do not email your assignment to a TA or instructor! If you are having difficulty with your Blackboard account, you are responsible for resolving these problems with a TA or someone from IRT before the assignment it due. If you have any doubts, complete your work early so that someone can help you.