COM S 327, Spring 2017
Programming Project 1.03
Path Finding

So far, we've got this lovely dungeon. And we can. . . save and restore it. And, you know. . . look at it.

And that's about it. Nice for mom's fridge, but otherwise kind of boring.

Once you have monsters (next week), they (at least the smart ones) will need to find a path to the player through the dungeon. To find that path, you'll need to implement a path-finding algorithm. We're going to have some monsters that can tunnel through walls and others that can only move through open space, so we'll actually need two slightly different pathfinding algorithms. In both cases we'll use Dijkstra's Algorithm, treating each cell in the dungeon as a node in a graph. For the non-tunneling monsters, we'll give a weight of 1 for floor and ignore wall cells (i.e., don't try to find paths through walls; this actually degenerates to BFS, and you're welcome to use that, but we will not require you to implement two different–if very similar–algorithms for this assignment). For the tunnelers, we'll have to use weights based on the hardness; cells with a hardness of 0 have a weight of 1, and cells with hardnesses in the ranges $[1, 84]$, $[85, 170]$, and $[171, 254]$ have weights of 1, 2, and 3, respectively. A hardness of 255 has infinite weight. We don't have to assign a value to this. Instead, we simply do not put it in the queue.

A naïve implementation will call pathfinding for every monster in the dungeon, but in practice, every monster is trying to get to the same place, so rather than calculating paths from the monsters to the player character (PC), we can instead calculate the distance from the PC to every point in the dungeon, and this only needs to be updated when the PC moves or the dungeon changes. Each monster will choose to move to the neighboring cell with the lowest distance to PC. This is gradient descent; the monsters move "downhill". Unless the monster is already collocated with the PC, there is always at least one cell with a shorter distance than its current cell. In the case of multiple downhill cells having the same distance, the monster may choose any one of them.

Dijkstra's Algorithm is described here: http://en.wikipedia.org/wiki/Dijkstra%27s_algorithm Scroll down to find the pseudocode under "Using a priority queue". Obviously, you'll need a priority queue, one with a decrease priority operation. You may use the Fibonacci queue that I provided with my solution to 1.01, or you may implement (or use a properly-attributed third party implementation of) any other priority queue you like.

My corridor building code uses Dijkstra's algorithm, so you may start with that (it won't require much modification) or start from scratch.

To test your code, select a random floor point in the dungeon for your PC, which you will render with an '`@`'. Render your dungeon with the PC. Then render your non-tunneling monster distance map, still marking the PC with '`@`' and marking distances using the last digit of the distance from the PC as calculated by your pathfinding algorithm (see image). Repeat for the tunneling monster distance map. Note that your distance maps will be integers from zero to some max value. We are only *displaying them* using the values above, not storing them that way.

Your submission, when run, should generate a dungeon, calculate all distance maps, render all three views of the dungeon, and exit.

All code is to be written in C.

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       33333333                                                               2111111
       32222222                                                               2100000
       32111111                                                               2109999
       32100000                                                               2109888
       32109999                                                               2109877
       32109888                                                                     6
       32109877                                                                     5
       32109876                                                                     4
       321098765432100                                                              3
       32109876      9                                                              2
       32109877      8                                                              1
       32109888      7                                                              0
       3      9      6                                                              9
       4      0      5                                                              8
       5      0      544                                                            7
       6      9        3                                                            6                                                  8890123456789012
       7      8        32                                                           5                                                  7       56789012
432109888     7          211                                                        5432100000000000                                   6       66789012
432109999     6            0                                                             09999999999                                   5       77789012
432100000     5            099                                                           09888888888                                   4       88889012
432111111     4              8                                                           09877777777                 210987655         3       99999012
432222222     3              7                                                           09876666666             65432       4         2       00000012
433333333     2              6                                                           09876555555            76           3         1
              1              5                                                           09876544444  44543210987            2         0
              0              44                                                          09876543333 33                      1         9
              9               3                                                          0987654322222                       0         8
              8               2                                                          098765432111    4321099999876543211 9         7
              7               21098                                                      098765432100    4321098888876543210 8         6
              6                   8766                   32109876543                     098765432109    4321098777765432109876555555555
              5                      5                   32109876  322                 2109876543210987654321098766666543210 8   4444444
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                                    3210999                3333222                   8                             9999999   4   7777777
                                    3210000                4443211                   9                             8888888   3   6666666
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      109876543                                                                  4                             9                098765433333
      10987654321098765432111111                                                 5                             8                098765432222
      109876543   98765432100000                                      654321098766                             7                098765432111
      109876544   98765432109999                                      654321098777                             6                098765432100
      109876555   98765432109888                                      654321098888                             5                           9
      109876666   98765432109877                                      654321099999                             4                           8
      1                        6                                      654321000000                             3                           7
      2                        5                                      654321111111                             2                           6
      3                        4                                      654322222222                           111111111                     5
      4                        3                                      654333333333                           100000000                     4
      5                        2                                      654444444444                           109999999                     3
      6                        1              321099999               655555555555                           109888888                     2
      7                        0              321098888               666666666666                           109877777                     1
      8                        9              321098777               777777777777                           109876666                     00
      9                        8              321098766               888888888888                           109876555                      9
      0                    2109876543210987654321098765               999999999999                           109876544                      8
     111234567             21098765           321098765432109876543210000000000000                                   3                      7
     222234567             21098766                              4                                                   2                      76
     333334567             21098777                              5                                                   1                       655
     444444567             21098888                              6                                                   109876543210987655555555  44
     555555567             21099999                              7                                                                  654444444   3
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                                  0                              8                                                                             4322222345
                                  1                              9                                                                             4321112345
                                  2                              0                                                                             4321@12345
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                           98765                         098765433                             3333334         99999901234567890
                098765432109                             098765444                             2222234         88888901234567890
                098765432100                             098765555                             1111234         77778901234567890
                098765432111                  10987654321098766666                             0001234         66678901234567890
                098765432222                  1          098777777                             9901234         55678901234567890
                098765433333                  2          098888888                             8901234         45678901234567890
                098765444444          098765433          09999999990123456789012345678901234567890123456789012345678901234567890
                                      098765444          000000000                                             45678901234567890
                                      098765555                                                                55678901234567890
                                      098766666                                                                66678901234567890
                                      098777777                                                                77778901234567890
                                                                                                               88888901234567890
                                                                                                               99999901234567890
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Here is an example distance map. The PC is near the lower right corner. Only the last digit of the distance is shown. You can get actual distances by counting the zeros along a path (sort of like reading elevations on a topographical map). Keep in mind that if you follow a non-optimal path in a circuit, you may have to count backwards! Pay attention of the gradients.