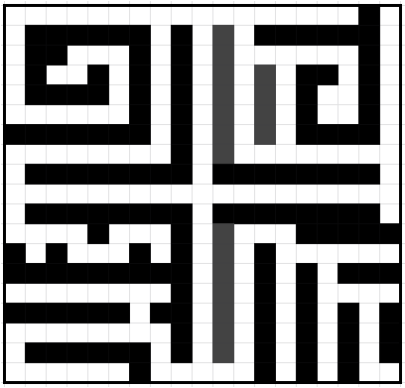
Final Exam Q1: Finding Your Way (50 Points)

16:198:520

Criminals have recently taken over the National Nuclear Power Station (NNPS) near your house, and are holding it for ransom. While the authorities seem powerless to stop them, you - plucky hero - decide to take matters into your own hands. You surreptitiously gain access to the internal networks, including the repair submarine drone that lives inside of the reactor core, which you'll use to safely shut down to reactor. Internal files indicate the inner layout of the reactor is as shown below:

Figure 1: TH23-SA74-VERW Reactor Schematic



The repair sub drone is capable of moving from cell to cell within the reactor, working on and repairing internal mechanisms. However, while you can issue commands to the sub drone (Up, Down, Left, Right), due to the manner in which you gained access, you don't have the ability to access the drone's sensors - you can command it, but you can't see where it is or get any feedback from it about its position. You are blind. But not helpless.

Question 1 (5 Points): Before you do anything, what is the probability that the drone is in the top left corner? Why?

Consider issuing the command 'DOWN'. While you don't know exactly where the drone is, you can say where it *isn't* - it isn't, for instance, in the top left corner anymore.

Question 2 (5 Points): What are the locations where the drone is most likely to be? Least likely to be? How likely is it to be in all the other locations? Indicate your results visually.

You realize that by issuing a sequence of instructions, you may be able to determine exactly where the drone is, and thus be able to use it to shut down the reactor.

Hint: If you are skeptical, consider the following simplified reactor schematic:

Why can you do that here?

Question 3 (25 Points): Write a program that takes a reactor schematic as a text file (see associated file for this reactor) and finds a sequence of commands that, at the end of which, you know *exactly* what cell the drone is located in. Be clear in your writeup about how you are formulating the problem, and the algorithms you are using to find this sequence.

What is the sequence for this reactor?

A Note on Expectations: There are many ways to formulate and solve this problem, but you should attempt to find the shortest possible sequence. Be clear and justify why your algorithm should output the shortest possible sequence, including any computational tricks or heuristics you might make use of. If you feel as though finding the shortest possible sequence is computationally infeasible, be clear and justify what you are doing to find a sequence that is as short as you can find. Solutions that are not guaranteed to find the shortest sequence may receive less credit, unless it is well justified why it should still generate short sequences. You can draw on anything from class in order to solve this problem. Your code should be commented, and it should be clear to the grader what each part of your code is doing, and that you know what your code is doing.

After saving the day and coming home from the parade thrown in your honor, the following question occurs to you: what is the reactor with the *longest* shortest sequence needed to locate the drone? Note that if the reactor had no internal separators and was totally empty, it would be easy to locate the drone; similarly, if the reactor had maximal internal separators to the point where only one cell was unblocked, it would be easy to locate the drone. The solution must be somewhere in the middle.

Question 4 (15 Points): Write a program that outputs a a 19x19 reactor schematic that has the longest possible sequence of commands needed to locate the drone that you can find. Be clear in your writeup about how you are formulating the problem, and the algorithms you are using to find this reactor schematic.

A Note on Expectations: There are many ways to formulate and solve this problem, though brute force is largely infeasible and unadvised. It is not required that you find the absolute worst possible schematic, but you should indicate clearly and justify why your approach will find bad schematics (forcing long command sequences). Less thorough and informed solutions may receive less credit. I would start with smaller dimensional reactors before scaling up.