Chapter 2 in the textbook begins our study of search with rudimentary uninformed search algorithms. It starts with representing data and choices as graphs and then covers basic techniques for traversing the graphs as well as the advantages and disadvantages of the different algorithms.

Questions:

1. Why is search an important component of an AI system?

   It is important because of the amount of data and the number of choices that are often being dealt with. Search is needed to determine the best possible answer given what is known. We as humans constantly add structure to the data we use so as to more effectively be able to find what we need from it. An AI system that does not attempt to emulate this in some way would not be very useful.

2. What is a state-space graph?

   A state-space graph is a data representation of all the possible paths that lead to a solution for a problem.

3. Describe the generate-and-test paradigm.

   In the generate-and-test paradigm you iterate over possible solutions and validate them as they are generated. While this is a trial and error approach, a good generator should be nonredundant and as informed as possible so as to provide possible solutions with a high level of potential.

6. Describe the greedy algorithm in a sentence or two.

   A greedy algorithm uses some method of ranking the available choices at any given stage. The choice with the best value is always the one taken.

7. State the Traveling Salesperson Problem.

   The Traveling Salesperson Problem attempts to find the shortest path through a weighted graph. The path must pass through each node of the graph only once and must end where it started.
Exercises:

7. Use Dijkstra’s Algorithm to find the shortest path from the source vertex \( V_0 \) to all other vertices in Figure 2.35.

Dijkstra’s Algorithm will choose the shortest path at each node that it has not previously chosen until it reaches its destination. It can only analyze alternate paths if they are between nodes it has already visited. The paths to each of the vertices would be:

\[
\begin{align*}
\text{\( V_0 \rightarrow V_1 \)} & = 4 \\
\text{\( V_0 \rightarrow V_1 \rightarrow V_3 \)} & = 6 \\
\text{\( V_0 \rightarrow V_1 \rightarrow V_3 \rightarrow V_2 \)} & = 7 \\
\text{\( V_0 \rightarrow V_1 \rightarrow V_3 \rightarrow V_1 \rightarrow V_4 \)} & = 7
\end{align*}
\]

8. Create a representation for a puzzle such as the 15 puzzle that is appropriate for checking repeated states.

One possible representation for the 15 puzzle could be to pack the values into a single unsigned 64 bit integer. First we would need to flatten the puzzle out into a single row of 16 pieces rather than 4 rows of 4 pieces. We can use 0 to represent the blank space. Since there are only 16 possible values for each space we only need 4 bits to store that value. Since there are 16 spaces and each space requires 4 bits, the entire game board will fit into an unsigned 64 bit integer. Checking for repeated states is then just an equality comparison.

For example creating a game board state could look something like this:

\[
\text{unsigned long long state} = (15ull << 60) | (0ull << 56) | (10ull << 52) | (2ull << 48) | (5ull << 44) | (6ull << 40) | (14ull << 36) | (12ull << 32) | (13ull << 28) | (11ull << 24) | (4ull << 20) | (9ull << 16) | (3ull << 12) | (8ull << 8) | (1ull << 4) | (7ull);
\]

which would represent a board that looked like this:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>
9. Solve the Missionaries and Cannibals Problem using breadth first search.

The representation of this problem is as such, m = missionaries and c = cannibals. The west bank is on the left and followed by a colon, the east bank is next and is also followed by a colon, the boat state is last. The boat state is w for west bank and e for east bank. Moves are attempted in the order m, 2m, mc, 2c, c. Repeated and failed states have been pruned from this graph.
10. A farmer with a wolf, a goat, and a container of cabbage are on the west bank of the river. On the river is a boat in which the farmer and one of the other three (wolf, goat, or cabbage) can fit. If the wolf is left alone with the goat, the wolf will eat the goat. If the goat is left alone with the container of cabbage, the goat will eat the cabbage. Your goal is to transfer everyone to the other side of the river safely. Solve this problem using:

The representation of this problem is as such, f = farmer, w = wolf, g = goat, c = cabbage, and the 2 river banks are separated by a colon with the west bank on the left and the east bank on the right. Moves are attempted in the order of fw, fg, fc, f. Repeated and failed states have not been pruned from these graphs so as to better illustrate the choices.

a. Depth first search
b. Breadth first search
11. Use bfs and then dfs to get from start node (S) to goal node (G) in parts (a) and (b) of Figure 2.36. At each step, explore nodes in alphabetical order.