Assignment 3

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(c) Optimizations:

- Changed the x and y coordinates in the Vertex class from int to short to lower the required memory of each vertex.
- Changed doubles to floats to halve the memory requirement of stored f values.
- f value added as a field to the Vertex class so that the fringe works as fast as intended. This significantly reduced run time.
- Changed closed list from ArrayList to Stack because pushing to a stack is constant time.

(d) Heuristics:

The best consistent heuristic we came up with was the euclidean distance from the current cell to the goal cell divided by 4 because this is the shortest possible distance, assuming that every cell is a highway cell. This is because h(n) at any cell n well never be greater than c(n,p) + h(p) where p is a successor of n. A diagonal distance heuristic divided by 4 should also be consistent, and it would be more appropriate for this grid world.

The other heuristics we tried were normal euclidean distance without the division, Manhattan distance, the example heuristic given in the PDF, diagonal distance (same distance as PDF example, different computation), and euclidean distance without the square root. None of these heuristics were consistent because they don't scale as well, but they required less computation time. These heuristics become more consistent with lower weight values in weighted A*.

(e) Regular A*:
Diagonal distance divided by 4 heuristic (consistent):

```
Average duration: 3723.44 milliseconds
Average path length: 183.00417
Average nodes expanded: 9984.06
Average memory usage: 20.29813632 megabytes
```

Normal diagonal distance heuristic:

```
Average duration: 123.98 milliseconds
Average path length: 147.58379
Average nodes expanded: 1519.58
Average memory usage: 18.54665552 megabytes
```

Euclidean distance heuristic:

```
Average duration: 232.04 milliseconds
Average path length: 154.28725
Average nodes expanded: 2131.04
Average memory usage: 19.95006704 megabytes
```

Manhattan distance heuristic:

```
Average duration: 37.36 milliseconds
Average path length: 149.55737
Average nodes expanded: 904.64
Average memory usage: 20.58225792 megabytes
```

Euclidean distance squared heuristic:

```
Average duration: 5.06 milliseconds
Average path length: 106.969086
Average nodes expanded: 120.96
Average memory usage: 17.7869728 megabytes
```