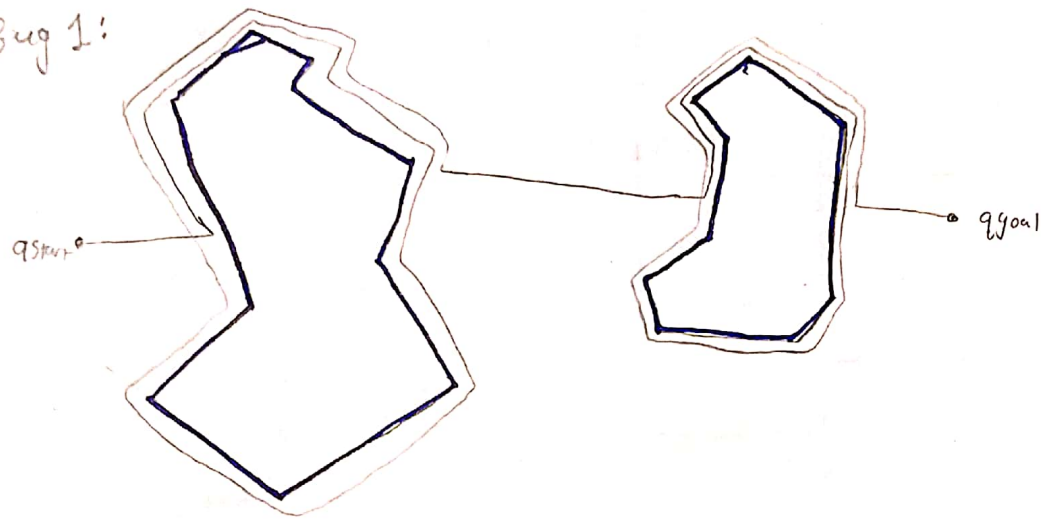
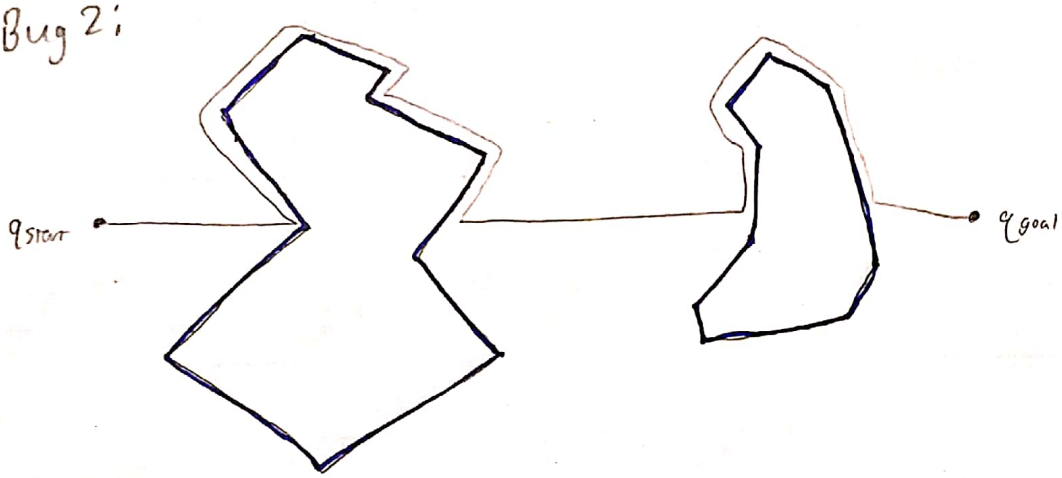
ASEN 5519 HW #1 | 09/07/2020 | LAOUAR, ZAKARIYA

1)

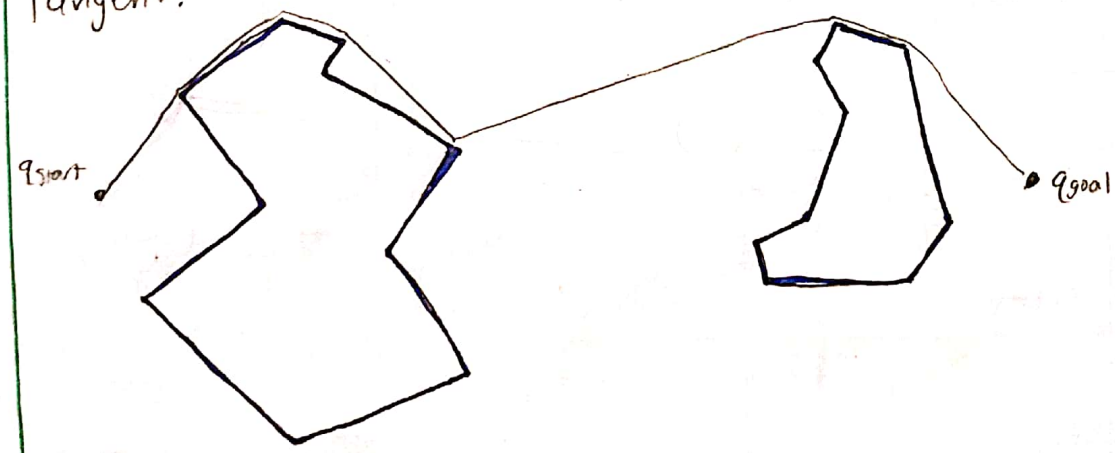
Bug 1:



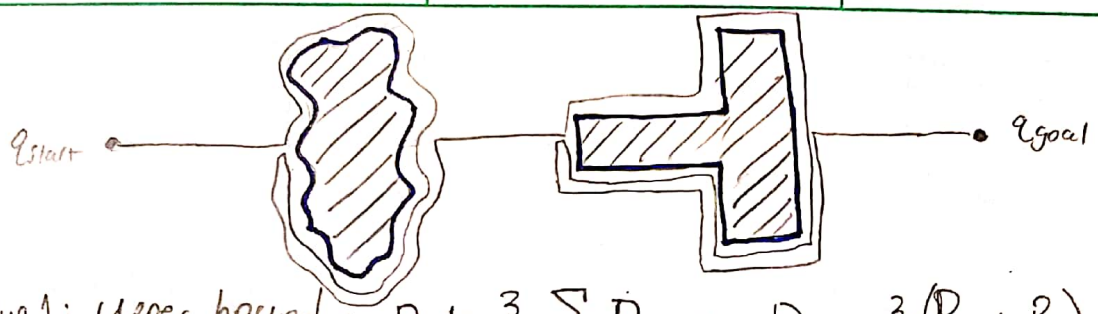
Bug 2:



Tangent:



2)



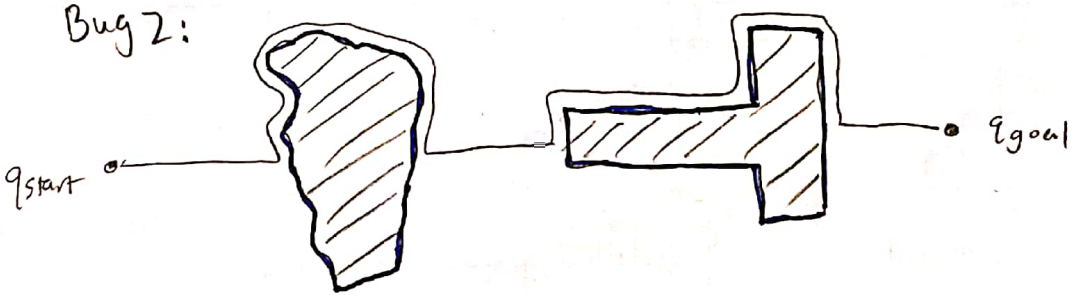
Bug 1: upper bound: $D + \frac{3}{2}\sum P_i = D + \frac{3}{2}(P_1 + P_2)$

Bug 2: The upper bound for bug 2 is: $D + \frac{1}{2}\sum n_i P_i$ where n = #m-line intersections with ith obstacle

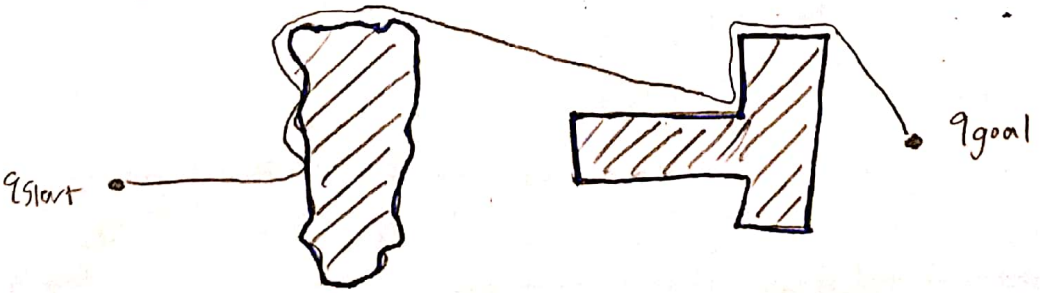
$= \boxed{D + \frac{1}{2}(P_1 + P_2) < \text{upper bound bug 1}}$

3) Bug 2 will follow the obstacle until the m-line is reached and then motion to goal or follow the next obstacle. Tangent bug with zero range sensing will follow the obstacle until it can motion to goal again.

Bug 2:



Tangent:



4) a) Bug 1 algorithm necessitates that the leave point is closer to goal than the hit point for a given obstacle

i.e. $d(H_i, goal) > d(L_i, goal)$ because L_i is closest point to goal on obstacle WO_i. It's impossible for $H_i = L_i$ because the obstacle must have finite thickness

b) Also, $d(L_i, goal) > d(H_{i+1}, goal)$ because the obstacles must not intersect with each other.

$\Rightarrow$ Phenoma (a) & (b) will continue $\rightarrow$, whereby the bug will NOT re-encounter already encountered obstacles, until the robot reaches the goal.

c) Through the Bug 1 algorithm, the bug will only encounter a finite number of obstacles since each H_{i+1} is closer to goal than L_i and we assume that any finite disc can intersect only a finite number of obstacles.

$\therefore$ the max number of obstacles is n

5) • Suppose tangent bug is incomplete (proof by contradiction)
• Therefore there is a path from start to goal (finite length and finite obstacle intersections)

• Tangent bug doesn't find the path
  • Suppose it never terminates
    • The bug will always motion to goal, moving towards the point that minimizes $d(x,n) + d(n, q_{goal})$ until the goal is reached or that distance begins to increase in which case the robot will switch to boundary following. since we assumed there is a path to goal, there will be a point on the obstacle where $d_{reach} < d_{followed}$.
    • Since we assumed a finite amount of obstacles, the goal will be reached and the algorithm will terminate.
  • Suppose it terminates (incorrectly). Then the robot will travel around an obstacle completely.
    • But since we assumed there is a path from start to goal, there will be a $d_{reach} < d_{followed}$ where the robot will motion to goal.

6.

1: While True do

2: repeat

Continuously move toward the point $n \in \{T, O_i\}$ which minimizes $d(x,n) + d(n, q_{goal})$

4: until

- the goal is encountered or
- the direction that minimizes $d(x,n) + d(n, q_{goal})$ increases $d(x, q_{goal})$ i.e., the robot detects a "local minimum" of $d(\cdot, q_{goal})$

5: Choose a boundary following direction which continues in the same direction as the most recent motion to goal direction

6: repeat

7: Continuously update d_{reach}, $d_{followed}$, and $\{O_i\}$

8: Continuously move toward $n \in \{O_i\}$ that is in the chosen boundary direction

9: until

- The goal is reached
- The robot completes a cycle around the obstacle → goal can't be achieved
- $d_{reach} < d_{followed}$
- robot unable to circumnavigate obstacle

adaptation ↓

10: repeat

11: perform Bug2 / wall following ... 1)

12: until

13: ☐ m line reached

end while

Table of Contents

Housekeeping

Variable Init

Bug1 Map1

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Warning: Ignoring extra legend entries.
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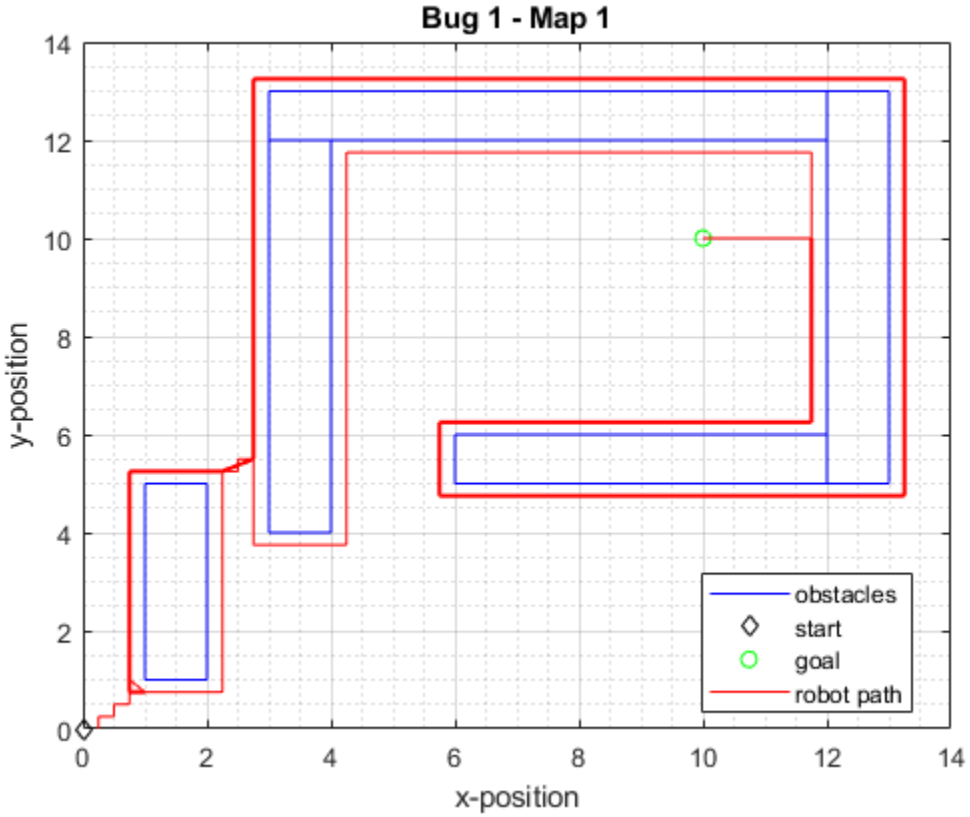
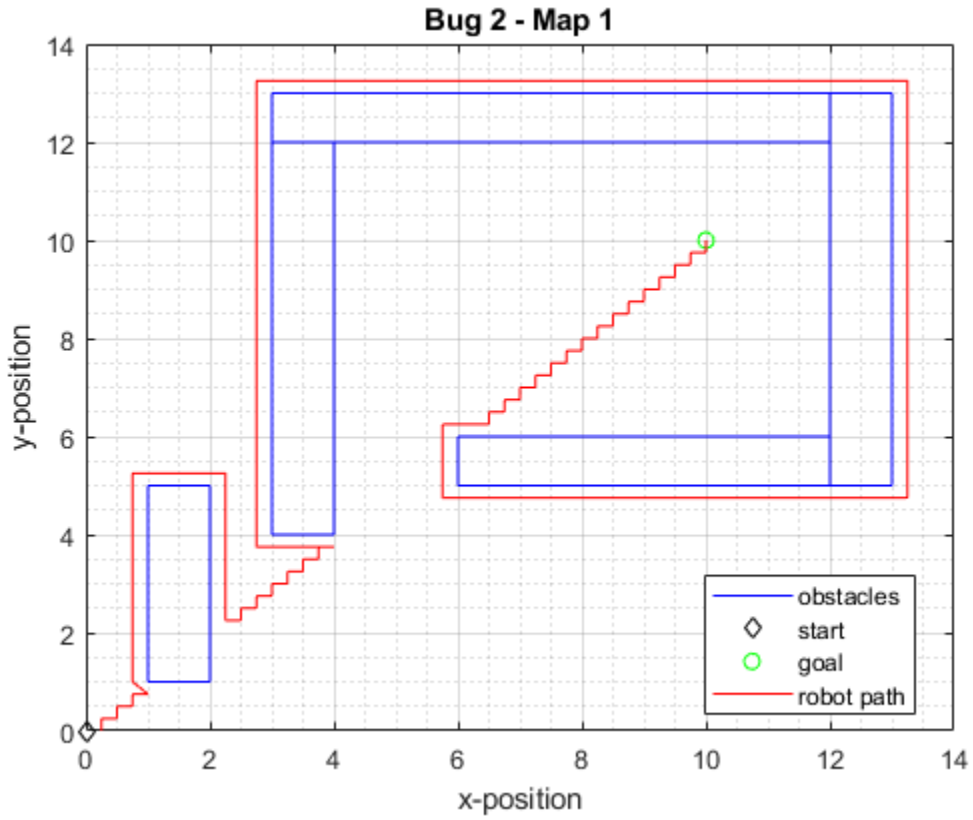


Bug2 Map1



Bug1 Map2

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Warning: Ignoring extra legend entries.
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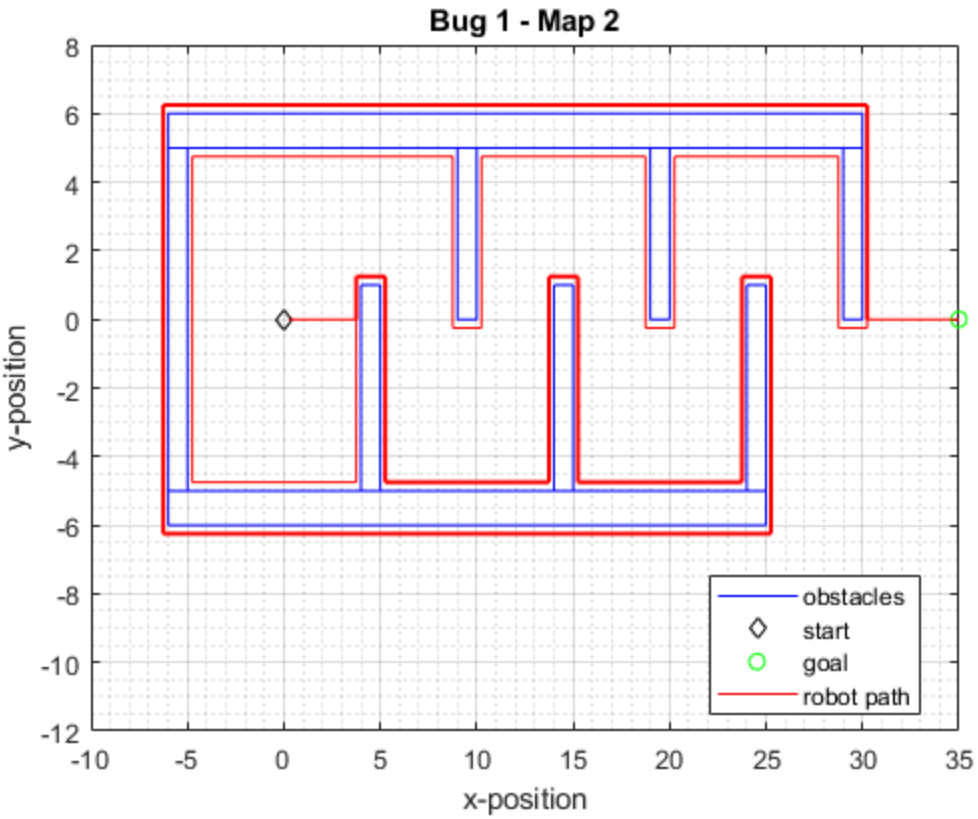
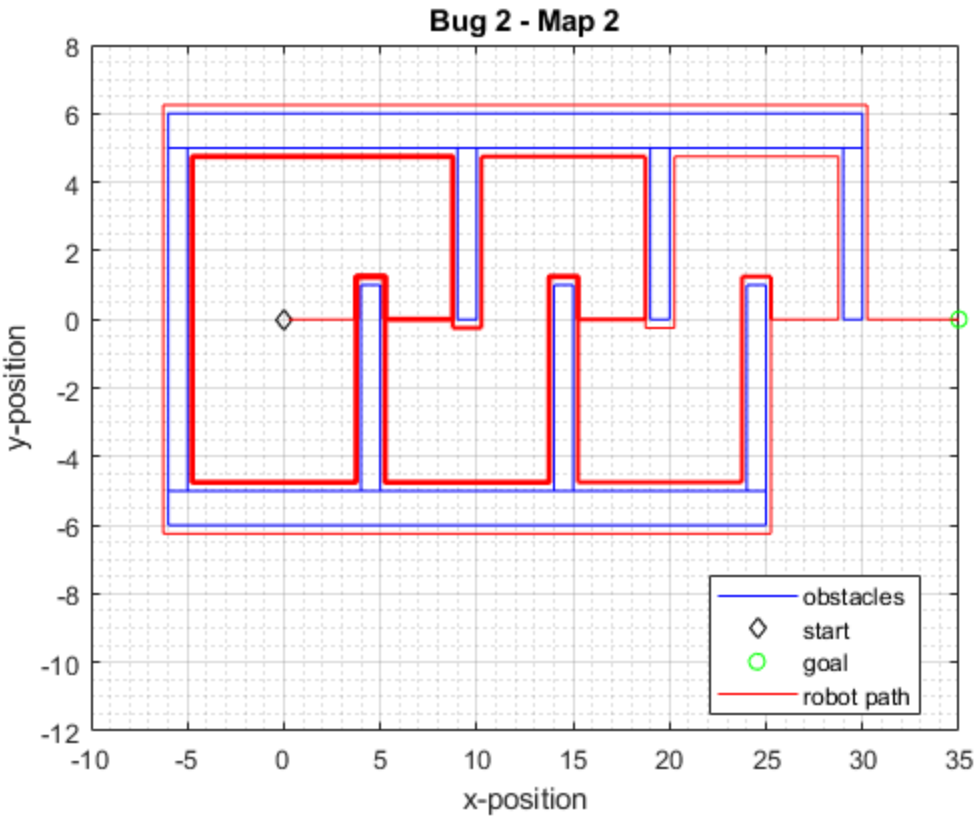


Bug2 Map2

```
Warning: Ignoring extra legend entries.
The path length for bug1 map1 = 133.500000
The path length for bug2 map1 = 60.250000
The path length for bug1 map2 = 373.250000
The path length for bug2 map2 = 419.500000
For the Bug 1 algorithm, I would expect the path length for a
right turning robot to be the same as for a left turning robot
because the robot has to circumnavigate the entire obstacle
regardless and then motion to goal at the closest point.
The upper bound on the path length is D+(3/2)*sum(obstacle_perimeter).
However, I would expect different lengths for the Bug 2
algorithm since the upper bound of the path length depends on
the number of m-line intersections and many of those intersections
could be further from the goal as the previous intersection thus
increasing the path length more.
```



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