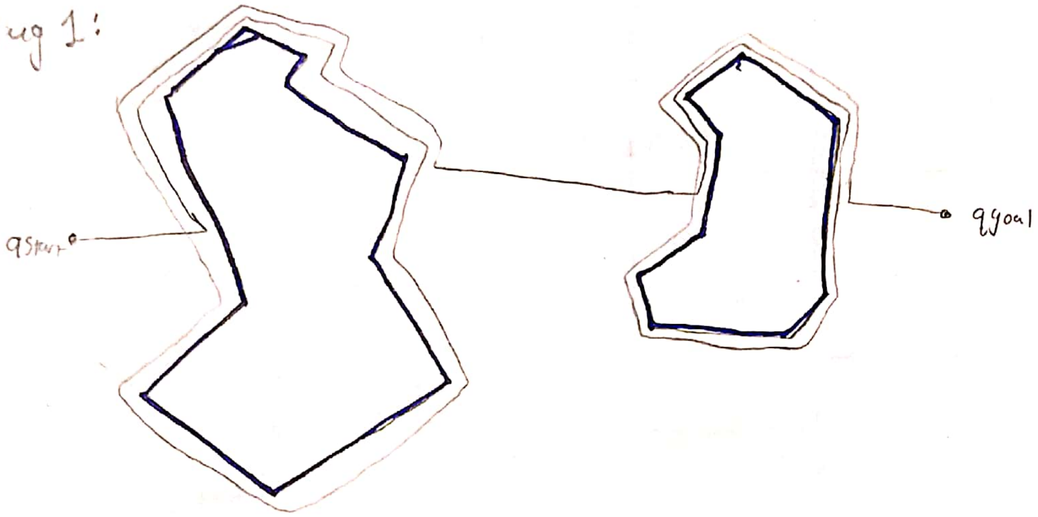
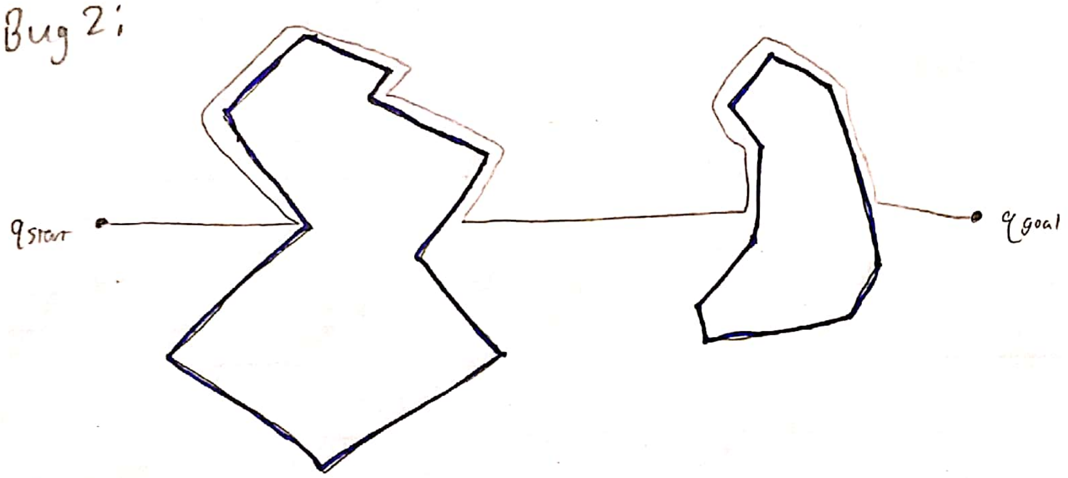
ASEN 5519 HW #1 | 09/07/2020 | LAOUAR, ZAKARIYA

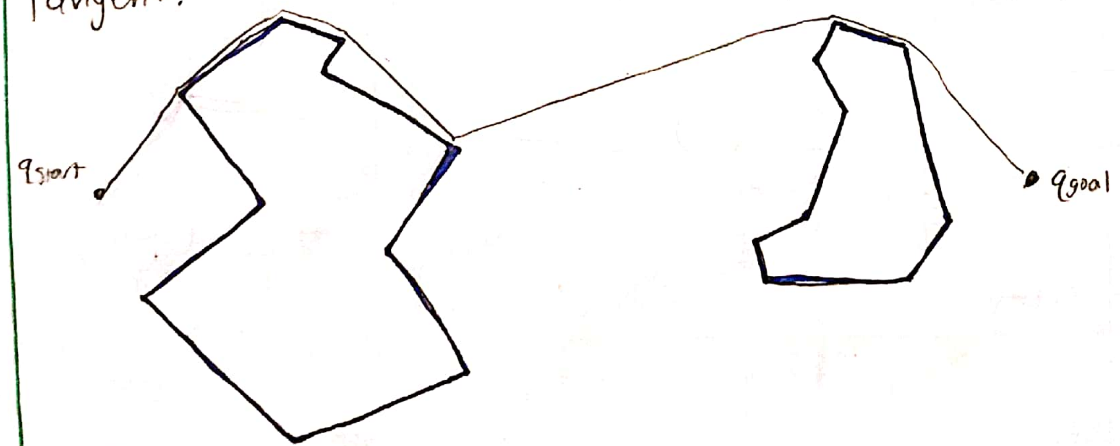
1) Bug 1:



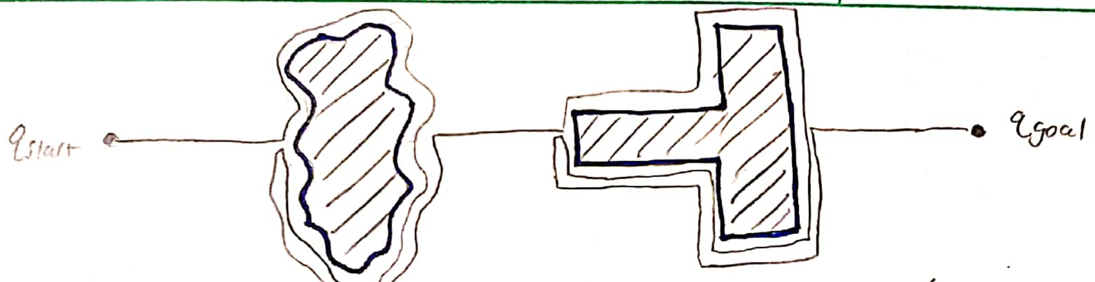

Bug 2:




Tangent:



2)



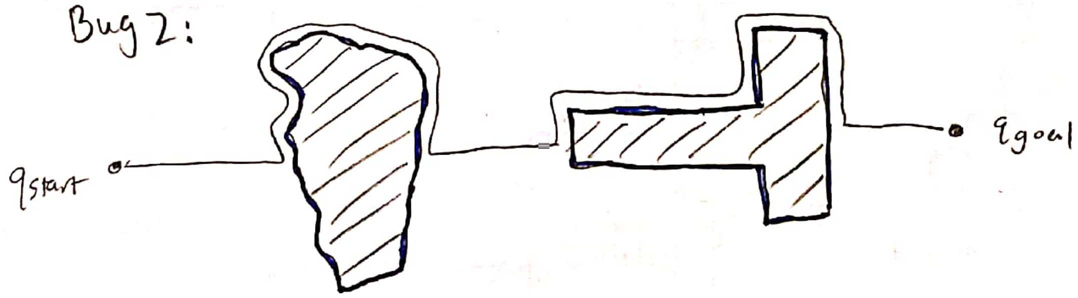

Bug 1: upper bound: $D + \frac{3}{2}\sum_i P_i = D + \frac{3}{2}(P_1 + P_2)$

Bug2: The upper bound for bug 2 is: $D + \frac{1}{2}\sum_i n_i P_i$ where $n$ = # m-line intersections with $i$-th obstacle

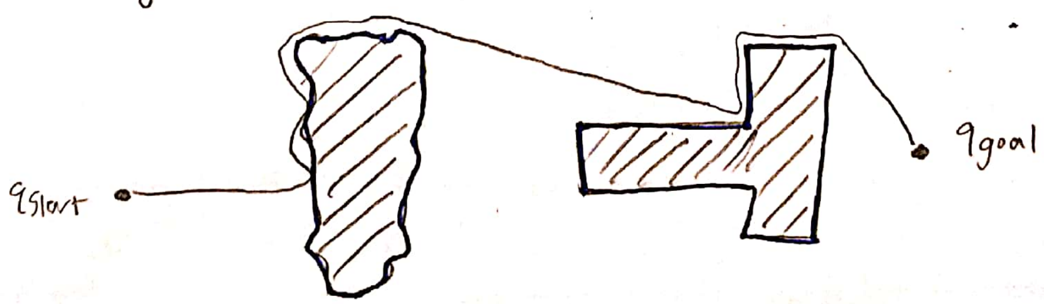
$= \boxed{D + \frac{1}{2}(P_1 + P_2) < \text{upper bound bug 1}}$

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 <u>impossible</u> 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.

⇒ Phenoma (a) & (b) will continue, whereby the bug will <u>NOT</u> re-encounter already encountered obstacles, until the robot reaches the goal.

c) Through the Bug 1 algorithm, the bug will only encounter a <u>finite</u> 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 <u>finite</u> number of obstacles.

$\boxed{\therefore \text{ the max number of obstacles is } n}$

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.

```
while True do
    repeat
        Continuously move toward the point n ∈ {T, O_i} which
        minimizes d(x,n) + d(n, q_goal)
    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(·, q_goal)
    Choose a boundary following direction which continues in the same
    direction as the most recent motion to goal direction
    repeat
        Continuously update d_reach, d_followed, and {O_i}
        Continuously move toward n ∈ {O_i} that is in the chosen boundary
        direction
    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
    repeat
        perform Bug2 / wall following
    until
        □ m line reached
end while
```

adaptation