ELEE 4200/5200: Autonomous Mobility Robotics
Term I, 2019
Homework 5: Drive Robot to Goal (Fast & Smooth)

Guidelines:

- Due date: Thursday, October 24, 2019 by 12 Noon.
- You are permitted to work in groups of no more than two students. State the full names and T# of the students in the group on the cover page of every document that you submit. Only one report needs to be submitted per group!
- Submit the report by responding to this assignment posting in Blackboard. The submission should at least include the following documents, bundled together into a single zip file with the name *YourNameHW5* (use one of the group member's names).
    - The main report in 'pdf' form (using the LaTeX template provided).
    - The MATLAB program code (as an m-file, so that it can be executed!).
    - Support documents like videos, etc.
- A separate hard copy (printout) of the 'pdf' report with MATLAB code listing; staple all pages together and follow the TA's instructions on how to submit the hardcopy. If you don't submit the hard copy, you will not get a grade for this homework!
- Each group must work on its own in completing this assignment! Feel free to consult with others in developing solution ideas, but the final code implemented must be your work product alone. Refer to the Syllabus, where the policy on academic integrity is clearly outlined, our classroom discussions on this topic, and consult with me and/or the TAs if you have any questions!

Broad Objectives:

a) To construct a program in MATLAB that drives a simulated Turtlebot (in Gazebo) smoothly and *as fast as possible* to a given goal through an intermediate waypoint. This assignment is a logical extension of an earlier assignment, where we made the robot drive a path contour, but there was no specific target position.
b) To do so with the use of motion feedback (output) rather than calculations based on drive commands (input).
c) To understand and deal with the wrap-around aspect of angle measurements in this task, due to their finite range of representation of ($-\pi$ to $+\pi$).

Specific Task Description: (read carefully and separate background problem information from requirements!)

a) Consider the available field to be a 10 m by 10 m square area. Think of it in terms of the "floor tiles" in Gazebo, each 1 m by 1 m. Remove all obstacles! The Turtlebot's initial pose, intermediate waypoint and final goal are shown in Figure 1; it has to face to the right at start time. The positions shown are with respect to the top left corner of the field. You might need to adjust the numbers in your Gazebo run! The Teaching Assistants will go over this with you and show you how to precisely position the robot at the starting position.

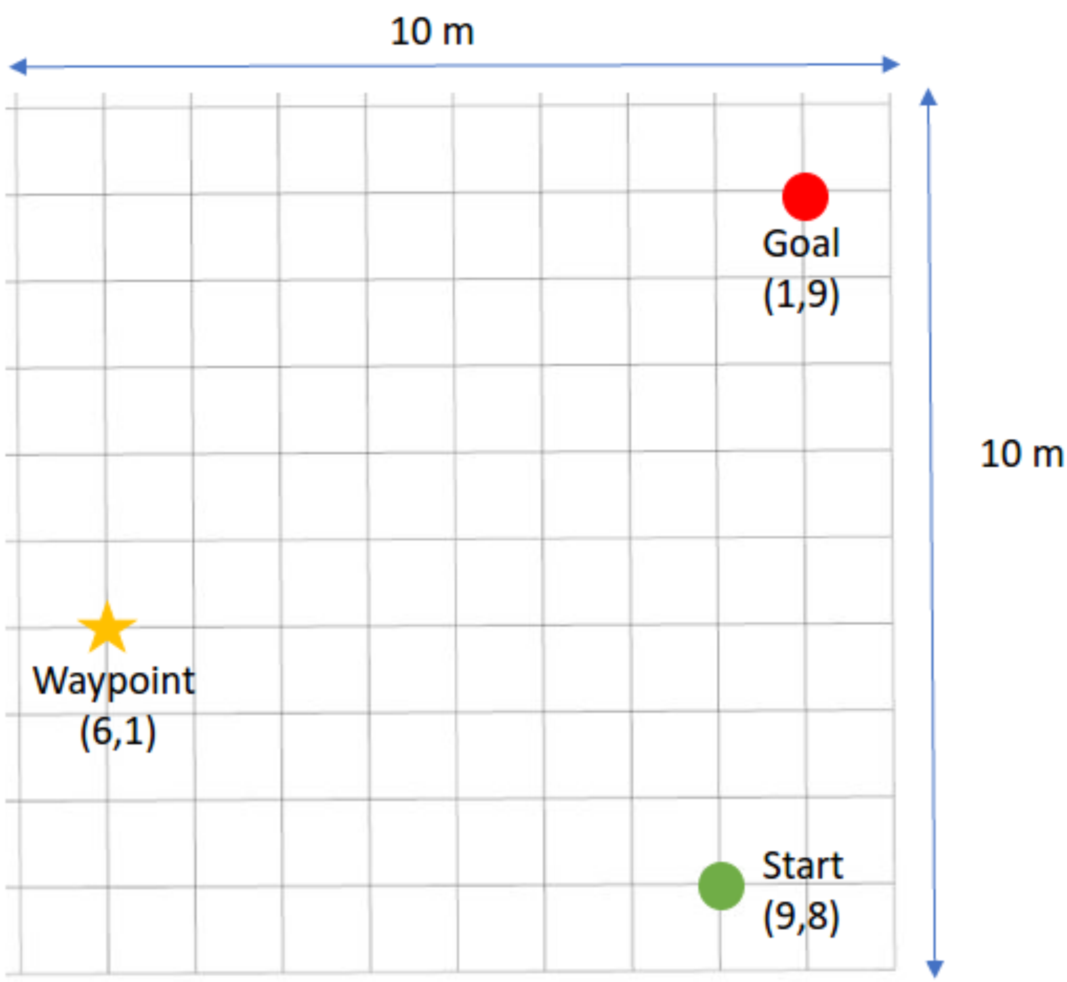

Figure 1

b) Drive the robot from the start position to the final goal position after going through the intermediate goal position. If the robot is within 0.5 m of a point, you can consider the point to be reached! You cannot exit the field at any time!

c) Do this as fast as possible and with as smoothly contoured a path as possible. The robot needs to be brought to a stop when it reaches the goal. Record the total transit time and report it. The group with the quickest time wins! Also estimate the total length of the path and report it.

d) The path contour is not necessarily a single circle or combination of circles. Think of how a human being would accomplish the move were she/he driving. This might give you some ideas. A pivot in place, followed by straight line motion to the goal is not allowed. Besides, this would not be the fastest way of driving to a destination! That is, you need to be moving forward as you turn towards the target point.

e) You must use motion feedback (through odometry) to drive, not just input velocity commands. The former is an output, while the latter is an input! Once again, just like in an earlier assignment, you need to construct the solution as a simple control loop based on basic principles.

f) Plot the path (x, y), the forward velocity, v(t), and the heading angle θ(t), as a function of time during the robot travel. These are quantities based on what the robot is doing, not what you are commanding it to do!

g) Using the results of part (f), make a focused argument on the smoothness of your drive. For example, the rate of change of v(t) and θ(t) might serve as good indicators of smoothness!

<u>Other information:</u>

- Deal with angles carefully!
- Learn how to use the "set model state" command. This command will enable you to start the robot with the same pose for repeated test runs.
- Explain your algorithm clearly in your report!
- <u>An important point to note is that *the process of arriving at the results is more important than obtaining results that appear correct, but you don't have any idea of how you got them!*</u> This is embodied in the following sequence of actions – an algorithmic idea translated correctly to code, examination of the attendant behavior of the robot in multiple experiments, modification of the algorithm to change or correct behavior desirably, then repeat this sequence as necessary.
- Produce some good videos of robot runs and include them in your submission.