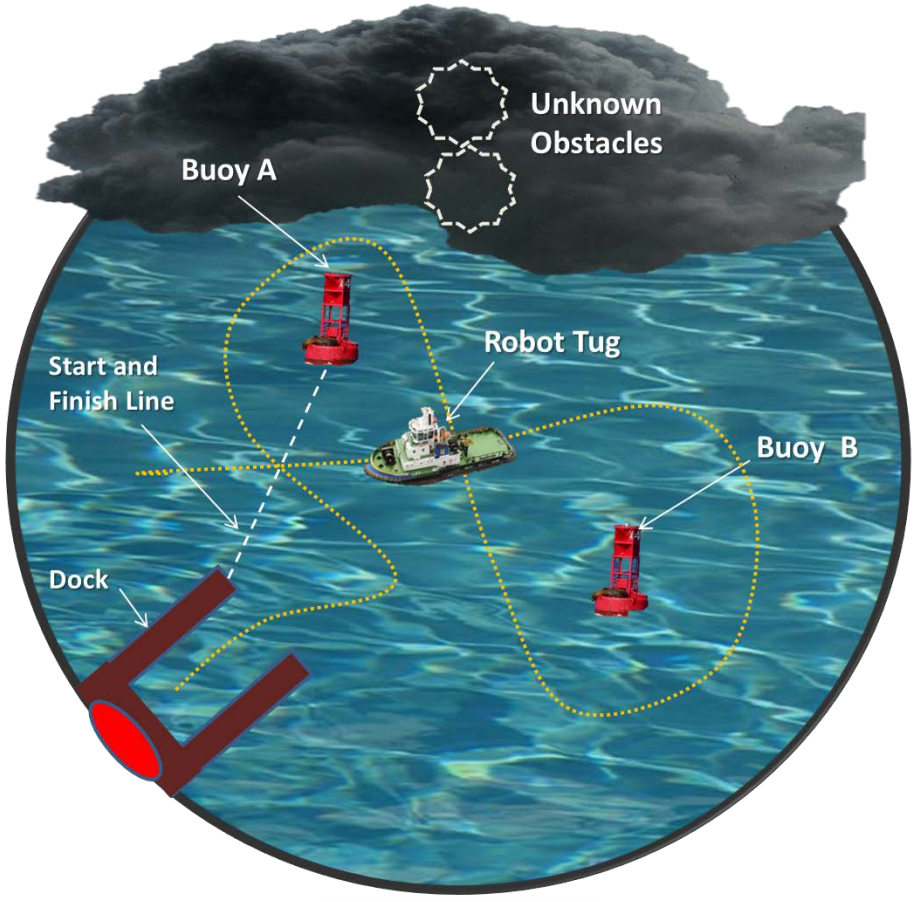
ENGR3390 Robotics: Final Project-RevA

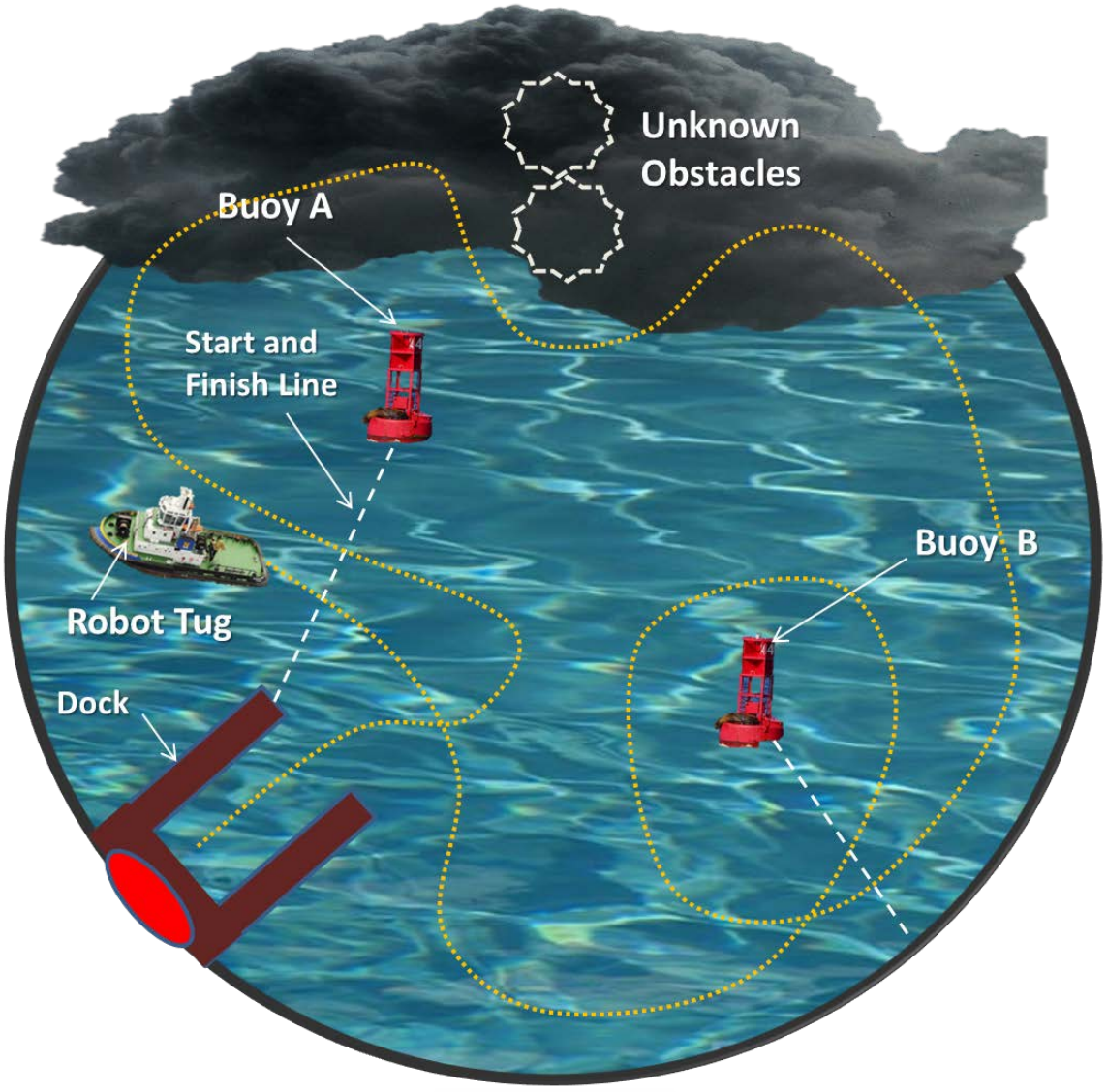
The Great 2014 RoboTugboat Race

Background: (Disclaimer, this is a purely fictional work, not in any way based on any actual people or events). In the not too distant future, your consulting team has been hired by a leading robotics manufacturer to pick up the pieces of a failed $15M internal project to build a viable Unmanned Robot Tugboat. The company had two previous internal teams working on the design. The program manager and senior staff for the first team quit when he realized that the company was moving out of the marine robotics business and would abandon the project and lay off his team regardless of how well they performed. A second team of young hotshot engineers were assembled to finish the program but were all lured away by Google-X labs to work on a secret robot project for astounding salaries before completing the work. Your team has been called in at the last minute to save the project, complete the robot-tugboats and do a final demo for the customer on Dec 11th. You will have full access to their incomplete designs and code repositories. The final demo consists of four parts:

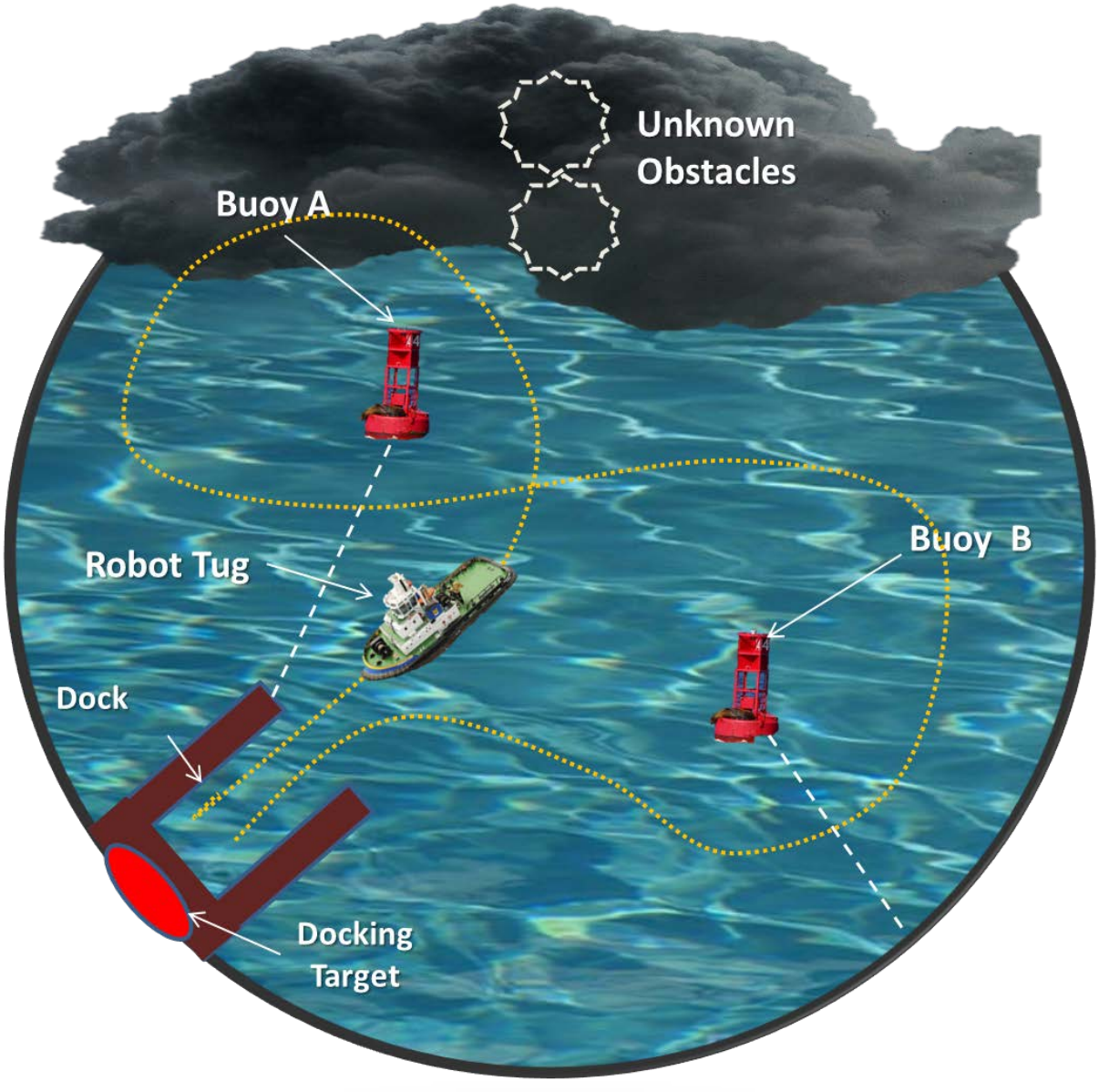
Demo 1: Robust GPS waypoint navigation (20 points). Tugboat must leave the dock south west of Buoy A, autonomously transit to Buoy A, round Buoy A on its Starboard side, round Buoy B on its Port side and then return across a line marked by Buoy A and Dock. Tugboat must navigate this in the shortest possible time, but in all cases must complete in less than 5 minutes (no points for completing in over 5 min). Any contact with any object along the way (shore, dock or buoys) will result in a 2 point penalty per contact (see graphic below).



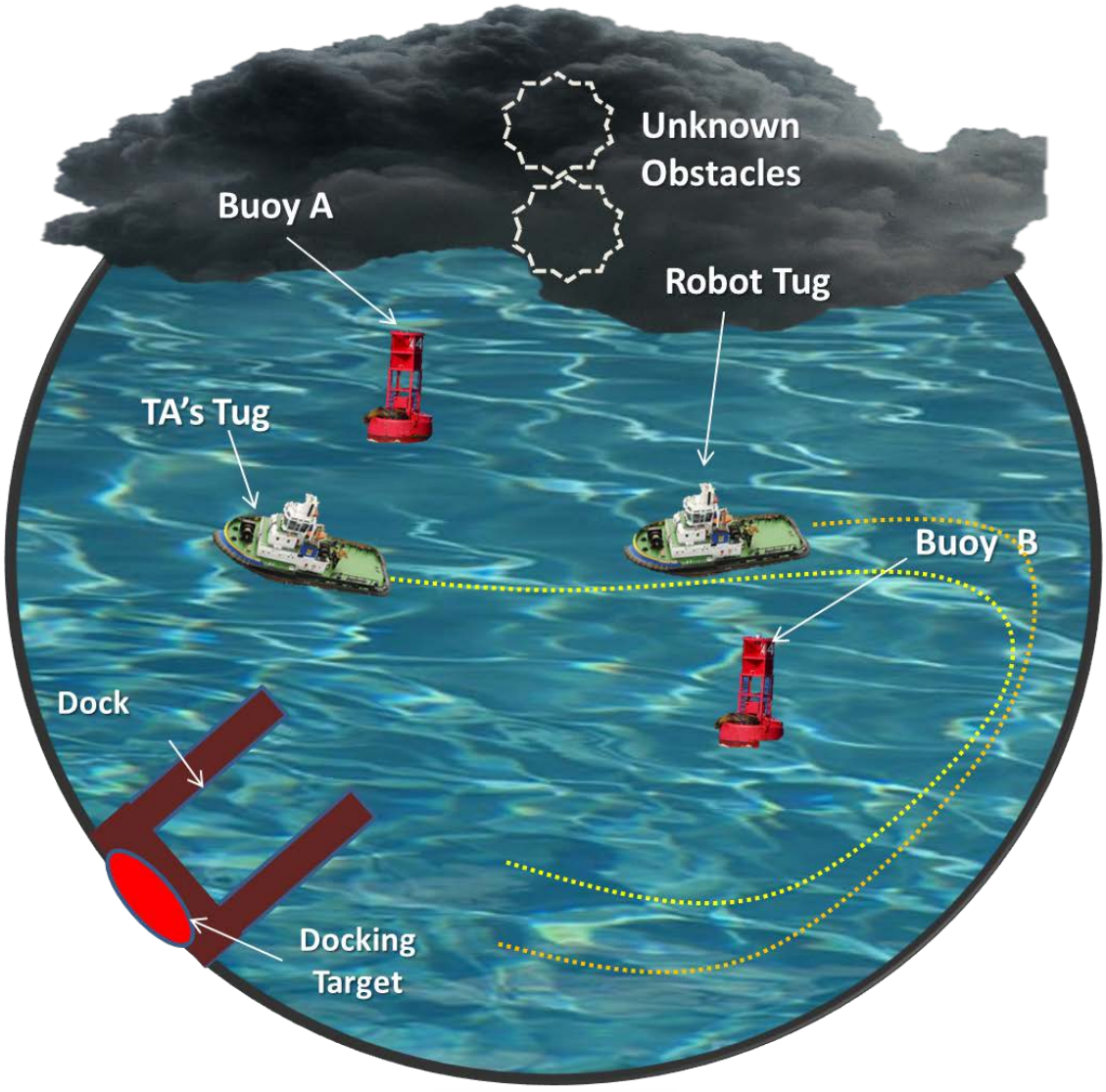
Demo 2: Robust GPS denied navigation with active obstacle avoidance (30 points). Tugboat must leave the dock, cross a line between dock and Buoy A, follow Portside shore at a distance of 1 boat length beneath the heavy electrical storm along the northern shore (where overhead GPS support will be denied), miss unseen (from overhead camera) obstacles beneath the cloud, follow Port shore until crossing a line between Buoy B and the port shore, circle Buoy B on the Starboard side once, then return to the starting line passing between Buoy A and the dock. Tug must run course as fast as possible and timed run will terminate when Tug crosses line between Buoy A and dock. Route must be run in under 5 minutes. Over 5 minutes is a disqualification. Any contact with any object along the way (shore, obstacles dock or buoys) will result in a 2 point penalty per collision.



Demo 3: Figure Eight with clean docking (40 points). Tugboat must leave the dock south west of Buoy B, autonomously transit to Buoy B, round Buoy B on Tug's Portside, round Buoy A on Tug's Starboard side and then cleanly dock using on-board tug camera and docking target circle (at end of dock) for guidance. Tugboat must navigate this Figure eight route in the shortest possible time, but in all cases must complete run in less than 3 minutes. Over 3 minutes is a disqualification. Any contact with any object along the way (shore or buoys) will result in a 2 point penalty per collision. Contact with dock, when docking is allowed.



Demo 4. Catch a moving target Tugboat (50 points). Tugboat must leave dock and then hunt down and catch the TA-Tugboat (which will be actively avoiding capture). Capture will be determined by clean physical contact between the chase boat and the target boat. Mission must be run in under 3 minutes total elapsed time. Any contact with any object along the way other than TA-Tug (shore, dock, obstacles or buoys) will result in a 2 point penalty per collision.



Successfully building the control for this robot tugboat will use almost all of the skills your team has acquired in the four robot course labs. The project will be held in the big test tank in the Olin project building. Each team will be supplied with an identical robot tugboat (please be careful with the boats. They are fragile, expensive, high performance robots and we have no spares. You break your boat and you will be held up while it is being fixed, putting your team at a serious disadvantage in getting a good final grade). The tugboats will carry an embedded MyRIO (Like Act Lab, a color camera (Like Vision Lab), and array of Sharp IR distance sensors (like Sense Lab) and will use a close variant of the robot brain you have already worked with (Like Think Lab). The tugboats have been converted to fly-by-wire control of the rudders and propellers from the MyRIO. Each tug will communicate with your team's laptops via the MyRIO's WiFi. Each team will also have access to a very high-end FireWire camera located above the Olin test tank in the project building to act as the overhead tug position GPS.

From the Sensor lab, you will need to bring your "find-the target" and "find-open water" tools to your familiar Sharp IR range detector (for wall following, as well as for obstacle avoidance). You will need to use these sensors in conjunction with the overhead camera to cover the spots obscured by the burning cloud. From the Vision Lab, you will need to bring the "find-the-target" tools to find and track the dock target. You will given some working code rom previous teams to find red circles.

From the Think lab, you will need to bring your "Forebrain-Midbrain-Hindbrain" tools to the task of building a robust layered control system that can accomplish the full demo mission. The Forebrain, Midbrain and The Hindbrain will run on the Tugboats MyRIO embedded computer. The Forebrain can communicate with a OCU (Operator Control Unit) code running on your laptop and both can do the deliberative planning required for each mission. The Midbrain will accept behavior mode, velocity and direction command coming down from the Forebrain arbiter. The Overhead camera will broadcast a global "Where-am-I?" sensing capability to all boats all of the time. You will need to write a new set of follow wall, round buoy, open-water transit, hunt boat, etc. behaviors at the midbrain to successfully accomplish the full mission. You will need to modify the Forebrain to handle the four demos of the overall mission. All coding on your laptops and the MyRIO tugboat computer will be in LabVIEW.

From the Act lab, you will need to bring your controls tools to the hard task of getting the tugboat to move from where it is to where you want it to be. This will be a challenging problem with full vehicle dynamics entering your control loops for the first time. The robot tugboat has beautiful dynamics with counter rotating propellers and dual rudders, and the pool is a controlled environment, but developing a stable control for it may be the most challenging aspect of this lab.

The overall demo will be run as a race between the 4 teams in the class. The race will take place on the final day of class. Each team will be allowed to run the course once for each demo with their total score the algebraic sum of points they win in each demo. Each run will be terminated after the 3 to 5 minutes allotted to let us run all teams and all demos within the normal class time. Only one team boat will be on the water at any given run.

The points per run will be awarded by the following metric:

1) Demo 1: Successful completion (20 points).
2) Demo 2: Successful completion (30 points).
3) Demo 3: Successful completion (40 points).
4) Demo 4: Successful completion (50 points)
5) Hit pool wall, buoys, dock, obstacles (-2pts per contact up to a maximum of the demos full points).
6) Sink Tugboat (fail project).
7) Fastest time to complete course per demo (+10 point bonus).
8) Complete all three preliminary demos (+15 point bonus).

The winning team, if they can complete the final demo (Demo 4), will receive the added bonus of no report due and an automatic course grade of A for all team members.

Please note: This final project will use "performance based" grading. Your final project grade will be based heavily on how well your Robot Tug performs the 4 demos.

Your individual final report will be short and only on the part of the final project code that you wrote. I will ask for a detailed description of what code you wrote, how it worked in practice and why. If you don't carry your fair share of the team work, it will show up in this report and directly affect your grade.

Final project grade = (total demo score/2) points demo performance + 30 points for your individual report.

Your team will be provided with a fully operational robot Tugboat and the complete boat/ pool support setup. You will also be given access to and instruction in the robot code bases left by the last two teams on the project. In class today we would like your team to:

1) Engage in a quick project planning activity for how your team will develop a workable approach to attack this technical problem. As a final project, this challenge is intended as a summative fusion of all of the individual Sense-Think-Act development work your team has done in the previous 4 labs. It is strongly recommended that you plan to reuse/reposition your team's previous work to the maximum extent possible.
2) Divide your team into a Fore, Mid and Hindbrain sub teams and assign the technical work to be done to each team appropriately.
3) Your Forebrain sub-team should download the Forebrain code from the ENGR3390 course folder and use it as a spring board for your code. Writing a new forebrain from scratch in the short time before the demo is a recipe for complete programmatic disaster. Team should instead focus on adding and tuning new behaviors and refining forebrain arbiter. Strong design paths would include optimal trajectory planning and dynamic mission definition file updating.
4) Your Midbrain team will need to use Sense-Lab experience to determine what the Tugboat sensors can actually perceive, review the overall mission requirements and then begin to craft a new set of reactive Mid brain behaviors to accomplish each demo. Reusing well written behaviors between demos is a very good idea. As there is a strong penalty for collisions, developing several robust obstacle avoidance behaviors based on the sharp IR sensor array is warranted. Refining a clean wall following behavior with the sharp IR-rangefinder will let you seamlessly transit under the cloud where you will have no overhead information. It's strongly recommended that you borrow from the existing Think lab simulation to let you develop and test these behaviors and quickly try them out in the pool.
5) Your Hindbrain team will need to master the programming skills required to develop the Sense and Act code needed on the Tugboat's embedded MyRIO controller. You will need to pull in the sharp wall range sensor and send them up to the mid brain. You will need to accept a boat heading and speed form the midbrain and command the propellers and rudders appropriately based on it. In order to do both you will need to become familiar with the MyRIO Tugboat control computer and how to run LabVIEW on it.

The software you will be given is presented in a separate document.

Good luck with the final project. This lab has never been run before, so please expect some bumps along the way and see the course staff for help. We will modify the overall final demo based on what each team can do before demo day.

The ENGR3390 Robotics Staff.