Advanced Robotics: Navigation and Vision (ME/CS 132)
Term Project

May 3, 2011

Summary

The term project for Advanced Robotics: Navigation and Vision (ME/CS 132) will consist of development and implementation of a mobile robot navigator. Groups will be required to implement perception, localization, and planning algorithms on a mobile robot and choose a focus task from several topic areas. Groups will be required to demonstrate successful autonomous navigation of several environments more difficult than those seen in laboratory exercises. Groups will be required to present their approach and discuss their results in a class presentation and written report.

1 Challenge

Develop an autonomous mobile robot system (perception, mapping, localization, and planning) to navigate three environments more complex than the one presented in laboratory exercises. Groups will be required to develop code for perception, mapping, localization, and planning to navigate a mobile robot to a known goal position.

1.1 Navigation Task

Groups will be required to demonstrate navigation of the three environments to the teaching assistants before the last day of term project presentations (5/26/2011). Robots will have one minute to navigate to within a quarter of a meter of the goal position. Runs will conclude when the goal is reached, when a robot collides with an obstacle, when a robot goes out of bounds, or when the one minute time limit expires. Groups will be allowed up to ten trials during one-hour laboratory sessions per binary and can arrange time with the hardware to test their approach beforehand. A single binary (program) must be used to navigate all environments. If parameters are changed that modify the behavior of the system, previous experiments will not count towards challenge task completion. The best performance of the group will be used to grade the navigation results portion of the term project.

1.2 Focus Task

Groups will be required to select a focus task to complete for the term project. The focus task is a topic related to perception, mapping, localization, planning, or control beyond what has been demonstrated in laboratory exercises. Examples of focus tasks include:

- Implement a planner that uses graph search (e.g. A*) to navigate the robot through the environment.
- Implement a localizer using observations of the AR toolkit markers in the environment (see Figure 1).
- Implement a localizer that fuses odometry and scan matching.

- Implement a obstacle detector that combines laser and stereo camera data.

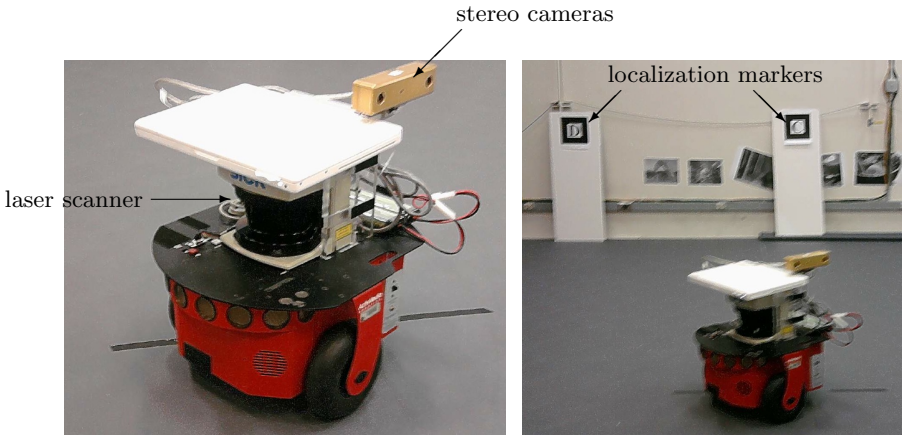
Groups can select from these focus tasks or develop their own (with instructor approval). All groups should strive to not only demonstrate the performance of their focus task topic but measure (quantitatively or qualitatively) differences in navigation performance.

2 Logistics

The experimental platform, groups, mentors, and important dates are discussed in this section.

2.1 Experimental Platform

We will use one of two Pioneer (Figure 1) mobile robots for the term project. The Player/Stage environment will be used for simulation development and testing of your navigation code. Code for the term project will be written in C/C++. Example world files for the three challenge environments will be provided to each team by 5/5/2011. Camera data sets will be provided as to each team as necessary (please coordinate with the teaching assistant or your project mentor). Navigation experiments will take place in the basement of Steele.



(a) Pioneer (b) Pioneer & Localization Markers

Figure 1: The Pioneer mobile robot outfitted with a laser scanner and a stereo camera pair.

2.2 Groups

Like the laboratory exercises, groups of three will be allowed to self form. Groups of four will be allowed with instructor approval.

2.3 Mentors

Each group will be assigned a mentor for questions regarding their focus topic. Mentors will be lecturers from the winter and spring terms of ME/CS 132 and will be assigned by matching selected focus task topic with expertise. Groups are expected to meet with mentors once a week during starting the week of 5/9/2011 to discuss progress, questions, and results.

2.4 Dates

Important dates for the term project are as follows:

Kickoff (5/3/2011) Details of the term project (including focus task options) are presented.

Group Organization and Focus Task Selection Due (5/5/2011) The composition and focus task topic of each group is due (email topics to me132-tas@caltech.edu). Term project advisers are assigned by the instructors by matching focus task topics with lecturer expertise.

Mentor Meetings (5/9/2011 - 5/24/2011) Meet once a week with your term project mentor to discuss progress.

Class Presentations (5/24/2011 - 5/26/2011) Thirty minute class presentations by each group on the design, implementation, and experimental results of the mobile robot navigation technique completed during the term project.

Written Report Due (5/26/2011) The written report describing the implementation and results of the mobile robot navigator developed during the term project is due by 11:59 PM on 5/26/2011.

Navigation Experiments Due (5/26/2011) The best performance by any binary (program) developed by the team will be used to grade the navigation results portion of this lab by 11:59 PM on 5/26/2011.

3 Grading

Grading for the term project will be a weighted combination of navigation task success, focus task results, and presentation. Each member in the group will receive the same grade. All group members are expected to participate equally throughout all facets of the term project.

Navigation Task Results [30 points] Successful navigation of the mobile robot in three environments within the one minute time constraint. The best performance of any single binary (program) will be used to grade the navigation results.

Focus Task Results [30 points] Implementation and demonstration of the focus task selected by the group. Measure (qualitatively or quantitatively) differences in mobile robot navigation performance.

Written Report and Class Presentation [40 points] Discussion of the mobile robot navigator developed by the group through thirty minute class presentation and a written report. All group members are expected to present during the class presentation and write portions of the report. Written reports are to be between six and ten pages long and discuss aspects of the implemented system and their experimental results.