Mini Grand Challenge Contest for Robot Education

Robert Avanzato

Penn State Abington
1600 Woodland Road
Abington PA 19001
RLA5@psu.edu

Abstract

The Mini Grand Challenge outdoor robot design contest was developed at the Penn State Abington campus to promote advances in robot education and technology. Partly inspired by the DARPA Grand Challenge, ground robots must navigate unmarked pathways on a suburban college campus and reach waypoint goals. Robots must also interact and entertain spectators during travel along the designated route. The contest facilitates and encourages the use of low-cost robot platforms in order to make the experience highly accessible to students and educators. A successful robot platform for less than $300 was developed by Penn State Abington for participation in the 2005 and 2006 contest offerings. The outdoor contest and low-cost platforms provide a challenging but accessible educational opportunity for robotics and AI education at the undergraduate and K-12 levels.

Introduction

The Penn State Abington Mini Grand Challenge robot contest requires battery-powered vehicles to navigate on 8-foot wide, unmarked, paved paths in a suburban, campus setting (see figures 1, 2). Robots must reach waypoints throughout a course approximately 0.5 miles (or less) in length. Orange cones are used to block non-course pathways (see figure 3). At the end of the paved path course (the last of 5 waypoints), the robot must leave the paved path system and cross an unpaved field to reach the final waypoint destination (figure 4, 5). Additionally, robots are expected to interact and entertain spectators throughout the course route. Participants are provided with the GPS coordinates of the waypoints prior to the contest. The contest is partly inspired by the DARPA Grand Challenge contest[1], but with an emphasis on accessibility and low cost.

A low-cost robot platform based on a commercially available PowerWheels™ electric car (~ $220) was converted into a suitable robot platform for this contest. The electric car was fitted with a servo (~$50) to control the steering through a bicycle gear and chain assembly. A hobby-grade speed controller (~$30) is used to control the motors for propulsion. A laptop running Windows operating system and MATLAB™ software (with image processing toolbox) communicated serially with an inexpensive microcontroller (example: HandyBoard, Basic Stamp, Pontech SV203; ~$100) and a GPS receiver (~$100). A USB web camera (~$30) was used for vision. An inexpensive sonar module (~$40) was chosen for obstacle detection. A powered speaker (30 watts; ~$150) is employed to communicate (make announcements, give warnings, tell jokes, play music, etc.) with spectators. The robot is shown in Figures 6 and 7 and is also described in [3]. The contest web page also lists suggested components for the robot platform [2].

With this system configuration, and the relatively low speed of the robots (1.5 to 4 mph), the students can use MATLAB for both algorithm development and for the deployed runtime software. The simplicity of the hardware platform and the software development environment provide access to lower-division undergraduate students. Students at higher levels may take alternative approaches. There are no restrictions on the choice of software or hardware tools and solutions for the contest. Educators can adapt this contest and select the appropriate tools to serve the education objectives of a variety of coursework or research. A full description of the Mini Grand Challenge contest rules are listed on the contest web site [2].

Contest Results

Four robots registered for the first Mini Grand Challenge event in April of 2005, held at the Penn State Abington, PA campus (Philadelphia, PA suburb); see Figure 8. (Due to rain, the event was postponed until December of 2005.) There was a

great deal of enthusiasm and interest in the outdoor robots from students and spectators. None of the robots were successful in completing any the course objectives. On April 1, 2006, the second annual Mini Grand Challenge contest was held with 6 robots participating. Contest participants ranged from undergraduate students to adult engineers and IT professionals. (The contest is open to all ages and affiliations.) Robot performance in the 2006 event was improved but no robot was successful in completing the first phase of the contest on the paved paths. Again, the level of interest was very high. The Penn State Abington undergraduate students who played a major role in the development of the robot and algorithms, and performed the systems integration and testing for the contest were all at the freshmen and sophomore levels.

Summary and Future Directions

The Penn State Abington Mini Grand Challenge outdoor robot competition was created to promote innovation in mobile robotics education and research, especially at the lower-division college and K-12 levels. The emphasis is on highly sophisticated, but low-cost and accessible robot technology that can be used as an educational tool. The contest and a low-cost robot were integrated successfully into a special topics robotics course for freshmen and sophomore engineering and IST undergraduates at Penn State Abington. Our future plans are to explore and document additional low-cost solution strategies and technologies, and to mentor a high school team for this outdoor robot contest.

Figure 1: Campus Path Example

Figure 2: Campus Path Example

Figure 3: Campus Path with Orange Cones
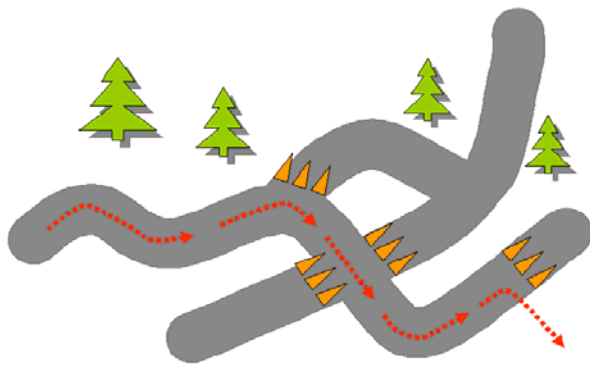

Figure 4: Campus Path at Last Path Waypoint

Figure 5: Campus Path Diagram
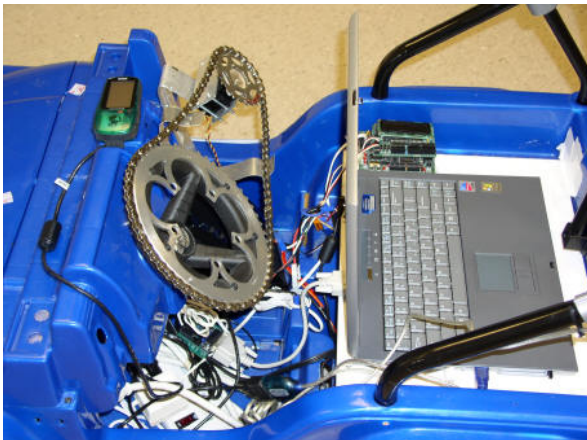

Figure 6: Robot with Camera

Figure 7: Robot with Laptop, Steering, GPS

Figure 8: April 2005 Contest

References

[1] DARPA Grand Challenge website: http://www.darpa.mil/grandchallenge/

[2] Penn State Abington Mini Grand Challenge website:
http://www.ecsel.psu.edu/~avanzato/robots/contests/

[3] Avanzato, R.L, "Low-cost Robot Platform for the Penn State Abington Mini Grand Challenge," Proceedings of 2005 AAAI Conference, Pittsburgh, PA.