Mobile Robot Navigation Contest for Undergraduate Design and K-12 Outreach

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Abstract
Penn State Abington has developed an autonomous mobile robotics competition to support freshman design, K-12 outreach, undergraduate research opportunities, and curriculum integration. The contest, Robo-TrailBlazers, encourages participants to explore a variety of robot navigation solutions including line-following, wall-following, and cooperating robots. Participants in recent contests have ranged from second grade to college seniors. The contest supports a wide range of educational objectives and promotes interest in engineering and science.

1.0 Introduction

Penn State Abington has developed autonomous mobile robotics educational resources to support freshman design, K-12 outreach, undergraduate research opportunities, and honors coursework in robotics [1,2]. One key component to the successful implementation of these activities has been the effective use of robot competitions. One contest, "Robo-TrailBlazers," has been designed to meet the educational needs of a wide range of participants. This contest has been offered at the Penn State Abington campus (Philadelphia, Pa. area) each December since 1998. The contest is free and open to students of all ages and backgrounds. The contest allows and encourages participants to explore a variety of navigation solutions including line-following, wall-following, and cooperating robots. The robots in the competition can also control the motion of an electric model train, which acts as a moving obstacle. Solutions have included simple "random walk" approaches, fuzzy logic-based line following, and mapping algorithms. A teleoperated division in which robots can be operated in a non-autonomous mode has been established for K-4th grade. Participants in recent contests have ranged from second grade to college seniors. The flexibility and accessibility of the contest support a wide array of education objectives including course integration, club activities, freshman design, science fairs, senior design projects, and more. An overview of the basic robot contest rules and strategies as well as results of recent competitions will be presented below.

2.0 Robot Contest Rules and Strategies

The objective of the Robo-TrailBlazers contest is to design an autonomous robot, or a collaborating team of robots, which is capable of navigating from a start position to a goal position, on a 8 foot by 8 foot flat arena, in a minimum amount of time (see figure

1). Robots must fit within a 12 inch by 12 inch by 12 inch volume at the start. A 4-inch high wall encloses the perimeter of the arena. Robots can choose a variety of strategies ranging from following a white line path to the goal, to navigating around obstacles and climbing over model railroad tracks to reach the goal. Alternatively, a wall-following approach can be employed, or a combination of strategies. A robot or robot team has a total of 3 minutes in the arena during which any number of attempts at the solution can be undertaken. The minimum time from start to goal position achieved by a robot or any member of the robot team at any time during the 3 minutes will be the score for that match. Robots within a robot team may communicate and cooperate in any manner. An electric model train will be blocking the white-line path on a grade crossing (see figures 1, 2, 3). The train can be commanded to move away from the crossing as a result of breaking a beam of IR light in the corners of the maze. The train will return to the grade crossing when the beam if IR is reestablished. The start position (18 inch by 12 inch area) is located in the southwest corner, and the goal position (18 inch by 12 inch area) is located in the northeast corner. The IR beams are located in the northwest and southeast corners of the maze. The control of the train by a robot is one challenge that encourages solutions involving a team of coordinated robots. In one approach, a robot in a team will be programmed to break the IR beam in order to allow the other robot in the team to pass the railroad grade crossing unhindered by the train obstacle.

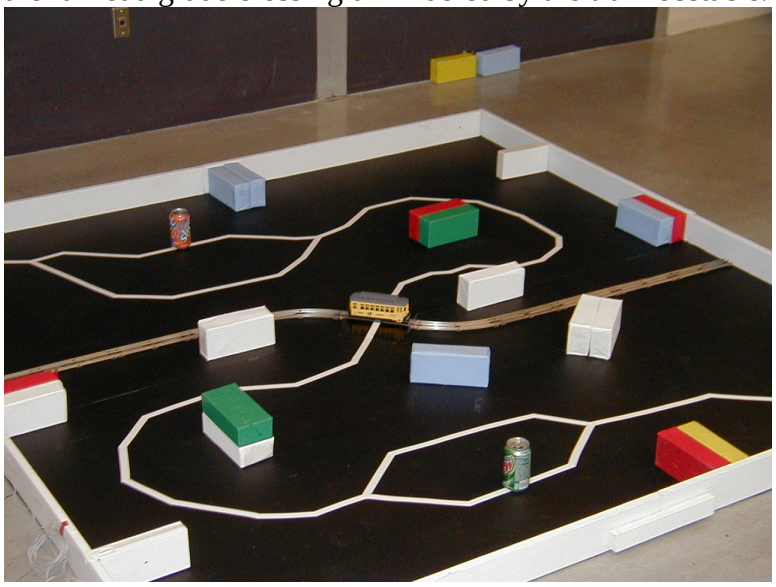

Figure 1

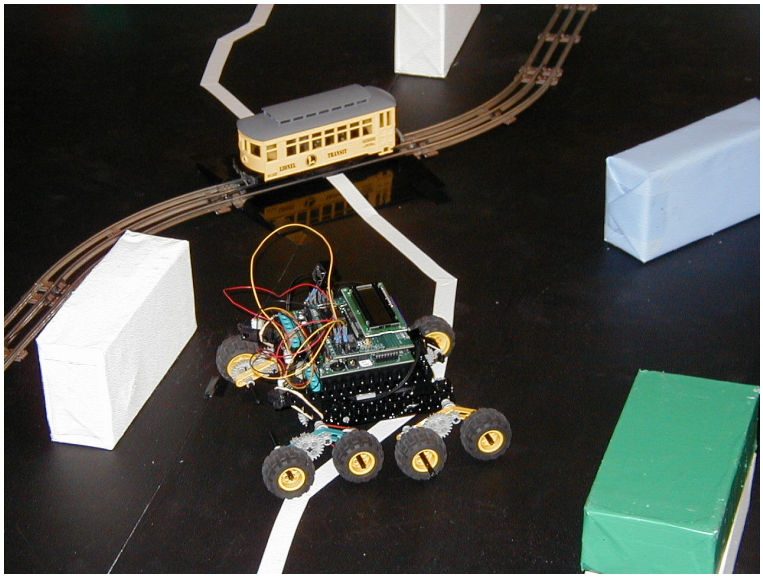

Figure 2

Figure 3

Empty soda cans are optionally placed on the white line paths and along the walls of the maze. If a robot manages to transport a can to the goal area, the robot receives a bonus. Obstacles (colored bricks) are placed randomly across the arena, and these obstacles are at least 12 inches apart. Robots must be fully autonomous and untethered, and there can be no human intervention during each of the two, 3-minute matches. In the K-4th grade division, remotely operated robots are permitted. Generally there a four divisions in which participants can enter: 1) college and professional, 2) high school, 3) middle school (5th through 8th), and 4) junior (K-4th grade). Detailed rules and specifications for the robot contest can be found at the contests website [2].

The philosophy of the contest is to offer an educational and entertaining event that is accessible to a wide audience and is low cost. The robot contest has been designed so that students at school or at home can easily practice and prepare without the use of high-

cost materials or labor. There are no constraints on the type of hardware or software used for the robots. Since the contest rewards simplicity and strategy, there are no serious advantages to those participants with access to high-cost and sophisticated equipment. The contest can be successfully approached with a low-cost robot such as the Lego Mindstorms [3] robot kit. Due to the flexibility of the contest, the contest is also challenging to college undergraduates, who can utilize the contest as an opportunity to demonstrate more sophisticated approaches. One of the benefits of a contest of this type is the interaction among participants representing a wide range of age groups and educational backgrounds. Overall, the participants, as well as parents, friends, and educators, view the event in a very positive manner.

3.0 Results and Conclusions

The annual Robo-TrailBlazers contest attracts between 12 and 20 robots from local colleges, high schools, and K-8 schools. The event is held on a Saturday, and is open to the public. Four high schools in the Philadelphia, Pa area have been participating in the robot events on a regular basis. In several cases the robot contest has served as the foundation for robot courses or activities at the high school. One high school student has used the contest as the basis for highly successful science fair projects. The growing number of K-8 participants has also been encouraging. Coordination of the robot contest with our summer workshop in robotics (4^{th} through 8^{th} grade) has improved the visibility of the event. The availability of low-cost robotics resources such as the low-cost Lego Mindstorms robot kits has also made the robotics more accessible to a wider range of students, especially in the K-12 category. Penn State Abington has also been offering a regional fire-fighting robot contest (developed by Trinity College) [2,4] in March of each year. Many of the students participating in the navigation robot contest are inspired to participate in the fire-fighting robot contest. Freshman and sophomore engineering majors at Penn State Abington have used the robot contest as design projects to satisfy design components of coursework, and as a focus for undergraduate research in the areas of robot navigation and fuzzy logic.

Overall, the robot contest has successfully served as a resource for undergraduate design, research, and K-12 outreach. Mobile robotics design competitions of this type encourage creative problem solving, teamwork, project management, research, and promote interest in careers in science, engineering, and technology. One of the positive features of the Robo-TrailBlazers contest is that participants are encouraged to consider a variety of solution strategies, including the exploration of cooperating robots. Due to the wide range of accessibility and depth, the Robo-TrailBlazers contest described in this paper can simultaneously satisfy many educational objectives and outreach goals in an efficient and effective manner. It is hoped that this contest can be used as a resource to educators with similar needs and requirements.

4.0 References

[1] Avanzato, R.L., "Mobile Robotics for Freshman Design, Research, and High School Outreach," Proceedings of 2000 IEEE Society, Man, and Cybernetics Conference, Nashville, TN, October 10, 2000.
[2] URL: http://www.ecsel.psu.edu/~avanzato/robots
[3] URL: http://www.legomindstorms.com
[4] URL: http://www.trincoll.edu/events/robot/

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