HARDWARE COMPETITIONS IN ENGINEERING EDUCATION

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Abstract *Hardware competitions such as robotics events are becoming a common occurrence in many engineering schools and technical conferences. In many instances they provide an opportunity for students to demonstrate and compare different design approaches, interact with other students with different backgrounds, and learn from each other. Design problems associated with competitions are often challenging open ended-problems that support various solutions in terms of hardware and software choices, strategies, cost, and effectiveness. Competitions have a great motivational effect and generate interest from students and from the public at large.*

INTRODUCTION

In the past two decades many hardware competitions have been established by various organizations and agencies as a way to motivate researchers and students to find innovative solutions to engineering problems. Robotics competitions in particular have increased in scope and number throughout the world and constitute a favored way to generate early interest in science and technology from students across the K-12 range. In Electrical and computer engineering particularly, there are many regional, national, and international events that invite teams of students to compete in engineering design.

In [1] a yearly robotics competition is organized by the National Aeronautical Space Agency (NASA) and other organizations and businesses to encourage and expose high school students to engineering by teaming students with engineers in the design of a competing robot.

Reference [2] offers an illustrative list of a variety of challenging robotics competitions. The Institute of Electrical and Electronics Engineers (IEEE) sponsors several student competitions. The relevance of these hardware competitions to engineering education is the subject of this article.

LEARNING BY COMPETING

Student competitions motivate students to produce the best possible design and therefore force them to learn and utilize all the necessary tools and techniques required to achieve a good performance.

Hardware competitions are in general organized as team efforts and allow students to work in groups with a variety of talents. In some cases, teams can be multidisciplinary and include students from different engineering and computer science fields. Several competitions require the design and development of a robotic vehicle and offer an opportunity to team students from mechanical and electrical engineering with computer scientists. Such teams usually distribute the design task according to their members' respective specialties. In this respect, hardware competitions also provide means of satisfying the Accreditation Board for Engineering and Technology (ABET) requirement that students be exposed to multidisciplinary team work.

Another major advantage of hardware competitions in engineering education is the possibility for students to compare their own design to a multitude of other designs. The existence and variety of alternative design solutions to a given engineering problem is a valuable lesson. Students get exposed to different approaches in solving the same problem and learn from other solutions. In regional, national, or international hardware competitions, interaction with other students provides an opportunity to compare educational experiences with that of other schools. A good ranking at a competition can serve as evidence of student learning for accreditation purposes.

Besides education, hardware competitions are an efficient way to poll a large technical expertise for innovative solutions to arduous engineering problems. Research on mobile robots, unmanned vehicles, and submersibles, as well as research on artificial intelligence and expert systems all benefit greatly from the design techniques and methods generated by a variety of robotics competitions. As examples of competition-based research, the Association for Unmanned Vehicle Systems and the United States Military sponsor annual competitions that cover autonomous ground vehicles, autonomous flying machines, and unmanned underwater vehicles [3]. The American Association for Artificial Intelligence (AAAI) sponsors mobile robot competitions aimed at addressing research issues in artificial intelligence that attract a world wide participation and audience [4]. The Robot World-Cup Initiative capitalizes on the international attraction of soccer and organizes Robocup [5], an annual contest that features soccer games between teams of mobile robots to generate research on artificial intelligence and multiple robot cooperation and communication [5]. The relevance of hardware competitions, particularly mobile robots, to research in Robotics and Automation and Artificial Intelligence is addressed in more details in [6]. These

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competitions have served as a catalyst to several advances in robotic technologies.

IEEE SECON STUDENT HARDWARE COMPETITION

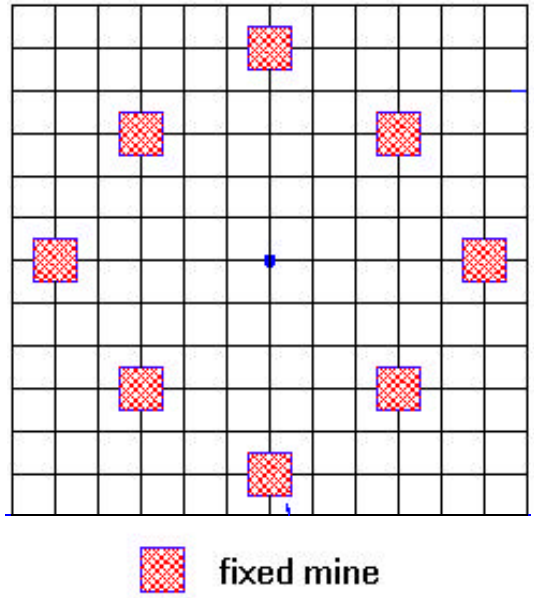
Examples of competitions that can be used to illustrate the relevance to Engineering Education include the Student Hardware Competition organized annually at the IEEE South East Conference.

In the 1998 competition [7], the topic was to build a robot that navigates its way from a starting point to the center of a square track. When the vehicle reached the center it activated a switch and started a process of turning on an infrared beacon at one of the corners. The robot was supposed to navigate its way to the corner beacon to turn it off by covering an optical switch near the corner. As one beacon shut off, another automatically turned on at another corner. The game ended when the robot successfully switched off beacons at all four corners. The order in which the beacons were switched on was random and a time limit was set for switching off all four beacons. To further complicate matters, the field included mines that carried a score penalty when triggered. The track layout is as shown in Figure 1, reproduced from the competition web site [7]. A successful robot in this event should have the following abilities:

1. Controlled drive and steering
2. Line tracking
3. Infrared beacon detection
4. Strategy -based software and hardware.

Many schools presented magnificent and clever designs but the winning entry was the simplest, least intelligent- in terms of hardware and software involved – but possibly the most clever. While most robots successfully tracked lines, detected the infrared beacons, and elaborately navigated their course to each corner while avoiding the mines, the winning robot, which had no sensors and a minimal electronic system simply circled the edge of the track at high speed a maximum of 4 times exploiting the narrow gap between the mines and the walls of the track. A valuable lesson was learned by all. The simplest, least sophisticated design with the simplest strategy turned out to be the best design for this competition.

Figure 1.



The 1999 Student Hardware Competition required the design and development of a robotic vehicle able to accomplish the following tasks:

1. Forward drive and steering
2. Line tracking
3. Pushing a button on a vertical wall
4. Picking up a precisely located metal ball
5. Dropping the ball at a different location
6. Climbing up and down a 15° incline
7. Pushing open a door
8. Navigating a path in the dark

More detailed information on this design topic can be found in [8]. At the University of West Florida, a team of six students designed two robotic vehicles, one of which earned first place making UWF the current champion in this competition. Figure 2 shows a picture of the two design projects and Figure 3 shows the team of designers.

At the time of this writing, at UWF, four teams of 3 students each have chosen to design robotic vehicles according to the specifications of the Student Hardware Competition to be held at the 2000 IEEE Southeast Conference [9].

Figure 2.

Figure 3.

ELECTRICAL ENGINEERING TOPICS

The robotic devices designed for hardware competitions allow students to integrate and demonstrate knowledge acquired in several courses in the overall engineering curriculum. Many designs incorporate at least the following systems:

- Power systems. Especially in the form of battery-powered circuits and voltage regulation. Students must also address issues in power consumption, power noise, and dealing with multiple voltage supplies and grounding problems.
- Motor control. Most designs include a minimum of two DC or stepper motors to allow forward motion and steering in a variety of arrangements. Motor driver circuits and control systems must be designed to accomplish proper motion of the robot.
- Transducer circuits. Many sensor systems are usually required and include position encoders, optical sensors, infrared or acoustic proximity sensors, collision switches, magnetic sensors, and others. Each sensor requires an electronic conditioning and interface circuit which may include amplifiers, filters, comparators, as well as Analog to Digital converters.
- Microprocessor circuits and embedded control. Most robots designed by students rely on a microprocessor system for control. Occasionally, Complex Programmable Logic Devices (CPLDs) may replace the microprocessor and most rarely, some robots will use analog control circuits.
- Programming. Invariably, students must program microprocessors to achieve satisfactory performance. Most often, programming in done in Assembly language, C or C++, or sometimes in VHDL when programmable devices are used.
- Mechanical design. Students have to build the robot and assemble motors, gears, frames, and other mechanical components.

This list provides one important reason for using hardware competitions in engineering design. Students get an opportunity to demonstrate and practice their skills and knowledge in analog and digital electronics, software, and hardware systems.

DISADVANTAGES OF STUDENT COMPETITIONS

One major disadvantage of every competition is that there is one winner and several losers. The education psychologists will be quick to point out that competitions are therefore harmful to many students' self-esteem. In college level student competitions however, the competitors have reached a level of maturity that minimizes the ego crush of

defeat. The positive feelings of accomplishment and the excitement generated by the competition somewhat temper and compensate for the disappointment of losing.

Another disadvantage is related to the extreme levels of motivation and excitement generated by student competitions. Quite often students tend to concentrate an excessive level of commitment to the design and development of their competition project at the expense of other, sometimes far more important, commitments such as other class work, or family involvement. The faculty advisor can play an important role in watching out for this problem and help the students balance their work loads.

CONCLUSION

This article has addressed the many benefits of involving students in Hardware competitions. Advantages of competitions include a high level of motivation, the possibility to involve students in multi-disciplinary teams, and the fact that hardware competitions constitute open-ended engineering problems that allow students to integrate knowledge from a variety of engineering courses. Another advantage in participating in national or international competitions is the unique experience of comparing different design approaches for the same engineering problems. Quite often, students will discover a variety of innovative solutions that they had not envisioned.

Most hardware competitions are enjoyable events where students have an opportunity to meet fellow students from other Engineering schools.

Some disadvantages of hardware competitions are inherent to any form of competition and include the elation of victory for one team but the agony of defeat for many teams. Also, one the major positive features of competition, motivation, can lead to neglect of other duties such as class work that is postponed or missed to work on the competition. Close faculty supervision can alleviate this problem.

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