Cybertech: Robotic Competition and Subject

Learning Mechatronics from a practical point of view

Pablo García-Robledo, Patricia García-Borrás, Ramón Galán
Universidad Politécnica de Madrid Madrid, Spain 28006
Email: (pgrobledo,patriciagb)@etsii.upm.es; ramon.galan@upm.es

Abstract—**This paper describes a subject and contest held in Universidad Politécnica de Madrid. This contest offers the students the opportunity of developing one or more robots so they can put into practice all their knowledge on electronic and mechanical systems. As a subject, all the students can attend a course in which they learn the basics on mobile robots. As a contest, it encourages all participants to improve their designs so they can win important prizes.**

Cybertech; robot; contest; subject; bull; fighting

I. INTRODUCTION

Robotic Competitions for undergraduate students are very popular nowadays. It has been demonstrated that this is a good method to involve the students in working teams and a way of teaching how real components work [1][2][3].

There are different contests all around the world where students develop different kind of robots for educational purposes, like Fire-Fighting [4], Robocup Junior [5] or Hispabot [6]. But other competitions are focused on reinforcing the research efforts on different areas, like RoboCup Soccer Competition [7] and RoboCup Rescue [8].

All these competitions have something in common, the participants must show a working robot which can perform the task and they compete with the others to demonstrate that their prototype is the best. This makes the participants try to do their best and consequently the results are better.

The Universidad Politécnica de Madrid has several engineering competitions, one of them is Cybertech. The Cybertech competition started on 2001 with only 96 students and has increased this amount until 2008 with 140 students. Cybertech is yearly held at Industrial Engineer Faculty. Any UPM student can participate in the contest and attend the subject, no matter what faculty he/she is studying at.

Cybertech is a contest and subject made for and by students. It is coordinated by one professor at the Industrial Engineer Faculty and organized by last year undergraduate students and postgraduate students.

The students are grouped into teams of four or five people to design and build one or various robots. They can decide what event they are going to take part. Participants also have to prepare an oral presentation of their projects.

There are several challenges in Cybertech: Line-Followers, Maze, Bull-Fighting, Solar Racers and RoboSim. These challenges are widely explained in section 2.

The competition usually takes places around April. Section 3 shows how the contest is organized.

The contest is also an elective subject for the UPM students. This subject represents six free election ECTS credits. The subject is related on section 4.

On section 5, there is a description of the material given and recommended to the participants. Teams with students registered in the subject are given the Arduino microcontroller so they can follow the coursework.

Section 6 shows the amount of participants in each Cybertech edition and the influence of different milestones in the number of students.

Last section explains some improvements for the upcoming years in the contest and subject.

II. THE CHALLENGES

A. Line-Followers

The most popular event in Cybertech is the line-followers. For this event, participants must build a robot that follows a black line over a white background.

This event has several difficulties in the robot's path. First

Figure 1. Line Followers Track.

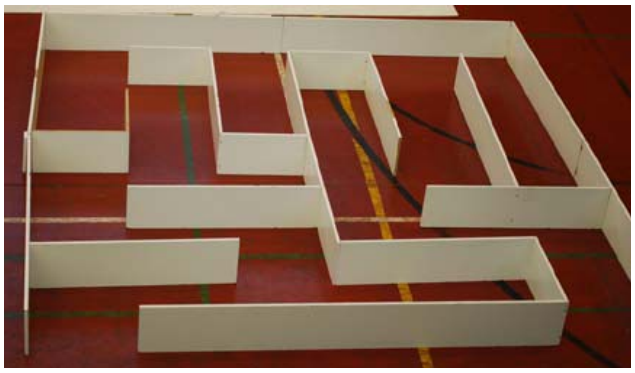

Figure 2. Maze.

of all, the robots must be capable of turning corners, which means in most cases that the sensors will lose the path. In second place, there are forks where the shortest path is marked so the robots can decide to take this way instead of the longer one.

The contest consists of three different trials. First of all, participants compete against each other trying to take as little time as possible to complete a path. There are two symmetric paths so participants can play two at a time.

The second trial is based on car races. This time four or more participants, depending on the amount of them, compete at the same time in a track with two parallel paths as seen in Fig. 1. The robots must be capable of overtaking one each other in case of collision. The semifinal and final trials bring the best participants face to face in a track similar to the previous one but with fixed obstacles they must overtake.

B. Maze

In this case, participants must do a robot capable of solving a maze. These robots usually are the smaller ones and use distance sensors to detect the walls.

The maze, as seen on Fig. 2, is made of white wood and can be changed by the organization.

In the first trial, participants know the maze map one day before the contest. In this case, they can think what the best strategy to solve the maze is.

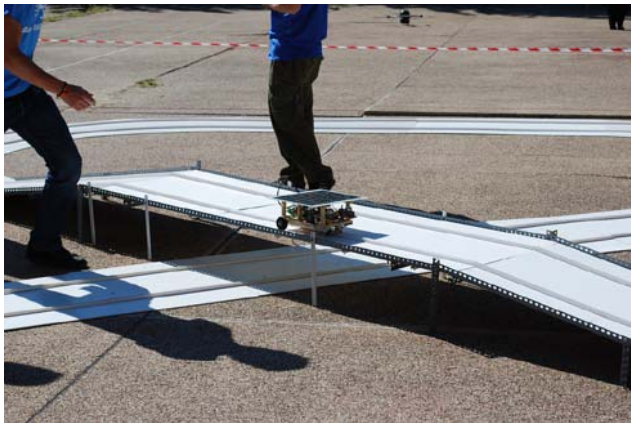

Figure 3. Solar Track

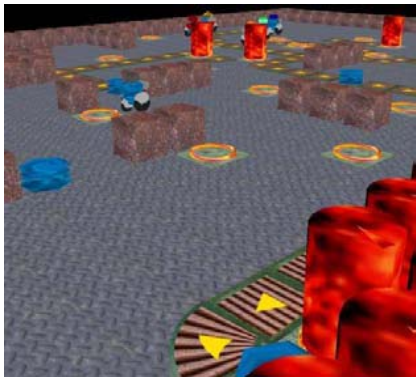

Figure 4. RoboSim Maze

Next trial's plane is given once the first trial is finished so they have little time to prepare their robots.

In the final, participants don't know how the maze is, so the robots must take their own decisions. These kinds of trials makes it unadvisable to program the map in the robot so it knows the maze. Participants usually have to research in common ways of solving mazes, which is an important part of the subject.

C. Solar Racers

One of the most important things that an engineer must take into account is that it is essential to know and improve new sources of energy.

In this event participants must develop a car which can move only by using solar energy. The cars must be capable of going up a slope and moving under a shade (Fig. 3.), but the amount of stored energy is restricted.

For this challenge the participants mainly develop the electronic power system and the chassis with motors. The car doesn't need to turn because there's a rail in the floor so the designers can concentrate in the power problems.

D. RoboSim

In this event the robots are virtually simulated in computers and participants must develop a computer program to control the robot.

Participants' program connects to the main server where a maze is held. This program must act as a robot in the maze, where there are different kinds of challenges and obstacles like fire or slippery ground as seen on Fig. 4. In each round all participants play at the same time and the one that gets first to the target earns extra points.

E. Bull Fighting

The Bull Fighting event makes the difference between Cybertech and any other robot contests. For years, participants had to fight against a bull given by the organization [9] but this was real hard to beat.

Figure 5. Bull Fighting.

Nowadays the participants develop both the bull robot and the bullfighter in the same robot (Fig. 5.). The bull robot has two pins in the front so it can attack the bullfighter, which has a balloon around itself.

The contest is as easy as trying to survive for several minutes the bull continuous attacks. It is also appreciated that the bullfighter gets near the bull instead of running ahead. As in real bullfights, the public will show white handkerchiefs at the end and the more they show, more points will earn the bullfighter.

III. CYBERTECH AS A CONTEST

As a contest, Cybertech is open to any UPM student who wants to participate and it is not needed to attend the subject. This makes Cybertech a really interesting event for the UPM as different faculties can try to win the contest. Nowadays there are students from Industrial Engineer, Computer Science, Aeronautical Engineer, Telecommunication Engineer and even, Agronomist Engineering participating in the contest as good as the Erasmus students. The contest normally takes place on Spring and lasts for two days. During the first day most of the events are held so on the second day only the participants who attend to semifinals and finals must come. It is done this way because the contest days are common school days so the participants must attend their lectures.

A. Cybertech International Contest

On 2008 there was a Cybertech International Contest in cooperation with BEST (Board of European Students of Technology) [12]. During one week 44 students from 20 European countries prepared robots for the bullfighting event. The students were grouped in teams of four people so each member in the team had different skills. The course's last day there was a competition between the teams to determine which one had done best.

IV. CYBERTECH AS A SUBJECT

There are two kinds of participants in Cybertech: the ones who only want to participate in the contest and the ones who are registered in the subject. These latter must attend a coursework that consists of four workshops.

A. Workshops

The workshops give the student a general idea about mobile robots. Each one of them takes almost four hours. The workshops are focused on how to develop a mobile robot for one or several challenges. During these workshops the students don't develop their prototypes; this must be something they do on their own so they can use their imagination.

During the first workshop, the students are introduced into several theoretical aspects of the subject such as microcontrollers, power supplies and how to program the controller. One of the most important things the students learn during this workshop is to solder electronic elements in PCB. They have to solder a motor control board which will be used in other workshops to control DC motors and in their final prototype.

The second workshop is focused on programming the microcontroller. Most students in Cybertech have never programmed before in C language, and none of them have programmed a microcontroller. It is then compulsory to explain how they can interact with the input/output signals.

Third workshop tries to give the students an overall idea on working with digital sensors and switches as well as how to control a DC motor. They must learn some common schematics to use sensors and how to filter the rebounds on the switch signal via hardware or software.

Fourth and final workshop is meant to introduce the students in the use of analog sensors. This can be a very wide field of study so they are only told how to use a specific sensor and how to measure the analog value in the microcontroller.

B. Tutorships

Once the students complete the workshops a tutor is assigned to each team. Usually a tutor has up to five groups of people during the year. The students must talk to their tutor regularly and tell him how they make progress. The tutor must answer all the questions the team could ask and depending on their knowledge he must encourage them to research more accurate solutions to their problems. When the team is made up of second degree people it is enough for them to achieve a

Figure 6. Workshop.

Figure 7. Team presenting their prototype.

working robot, but for last degrees it is common to ask them for better prototypes.

C. Presentations

All teams including a registered student in the subject must present their work in public. The presentation can't last for more than ten minutes and they must explain the main mechanical and electronic parts of their design.

As the presentations are done months before the contest, the teams are encouraged to present their robots as the best robots ever. It is also a way to make the teams work on their designs soon before the contest and consequently there are few last time prototypes in the exams.

D. Conferences

To improve the students' knowledge on robot systems, Cybertech organizes several conferences on different subjects each year. As an example, on 2008 there were three conferences on art and the relation with robots. During the conferences, severeral people showed how they could transform old computers and mechatronics into different sculptures or music instruments. In fact, we were glad to invite Carlos Corpa who showed how he and a Computer Science professor developed the poet robot PaCo. It was on 2005 when the most recalled conference was given by the Spanish astronaut Pedro Duque, who explained how different robots worked in the space. Since then, all the conferences are strongly recommended between the students, demonstrating how people are always interested in robots.

E. Exams and grades

Prior to the contest the teams have an exam in order to verify their prototypes. These exams usually are small events as the ones in the contest in which the participants must show that their robots are good enough to participate in the real events. The final grades are calculated as seen on equation (1). The most important result is the position in the contest (C), if a team wins the any of the events they are given top marks, but it is only needed to attend to obtain five points out of ten. The exam (E) and the presentations (P) have equal weights. Finally, the tutor (T) can give different grades to each team member depending on their work.

$$G = 0.5C + 0.2E + 0.2P + 0.1T \quad (1)$$

V. THE ROBOTS

All the robots must be autonomous and no bigger than an A4 paper sheet in area (less than 30x20 cm). It can't also weight more than five kilograms. It is absolutely forbidden to use a commercial robot in the competition, so all the robots must be hand made by the students. Fig. 8 shows several robots developed for the Line Followers Challenge.

The only exception to these rules is the bullfighters. These robots are made with a commercial base given by the organization which includes a PIC microcontroller and several distance sensors.

All teams including any student registered in the subject are given a set of material so they can attend the workshops. The following explains all the components.

A. Arduino

The microcontroller used in Cybertech is Arduino Duemilanove [10]. This controller is very cheap and enough for the purposes of the subject and contest.

To control a couple of DC motors the set includes a commercial Motor Shield [11] for Arduino Duemilanove. This shield can handle up to two DC motors. The shield is unsoldered out of the box so the students must solder all the parts in the first workshop.

B. Sensors

The students are free to choose the sensors they want to use, but the organization gives them a CNY70 which can distinguish between black and white over flat platforms. These sensors are analog sensors so they can use them to practice with analog and sensors and then they learn how to turn it into digital information with a simple inverter.

The other sensor that is recommended but not given to the

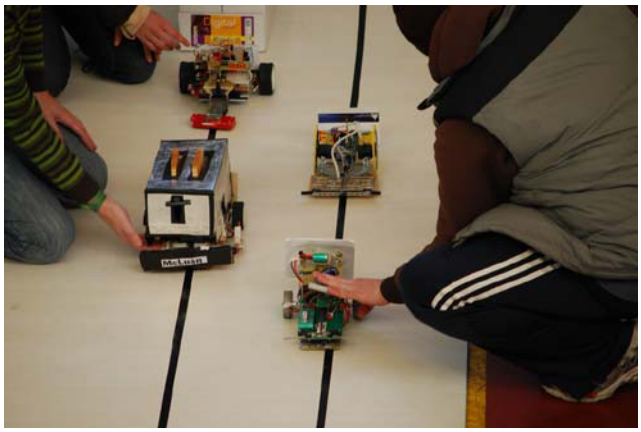

Figure 8. Line Followers Robots examples.

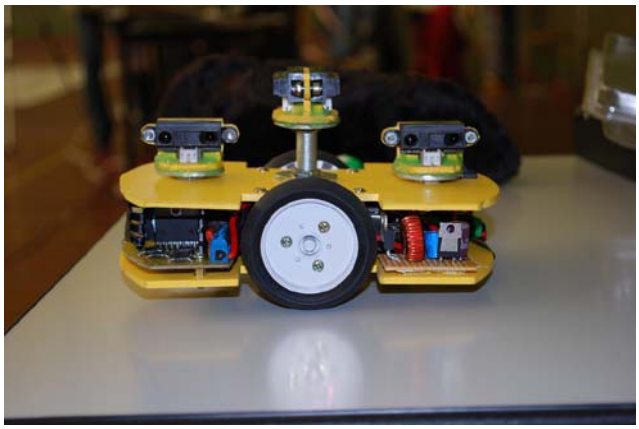

Figure 9. Robot developed for the maze event.

students is the GP2D12. This distance sensor uses IR and provides an analogical signal to measure the proximity of the objects. This can be very useful for line following participants so they can overtake without touching the opponent's car.

These sensor are widely used for the Maze event, for example, the robot shown on Fig. 9. has six distance sensors on it to detect the surrounding walls.

C. *Others*

The set of materials also includes different components as switches, leds, resistors and potentiometers. All this material is very useful during the lessons so the students can try different schematics and the interaction between the parts and the microcontroller.

VI. PARTICIPANTS

Since 2001Cybertech has had a lot of participants. Until 2005 there was no course related to the contest and, since then, the amount of participants has increased until 2008. The inclusion of the course resulted in the improvement of the prototypes and therefore a lot of rules had to be changed. As an example, the inclusion of obstacles in the line followers' track was done on 2006, making it impossible to win if the robots can't overtake them.

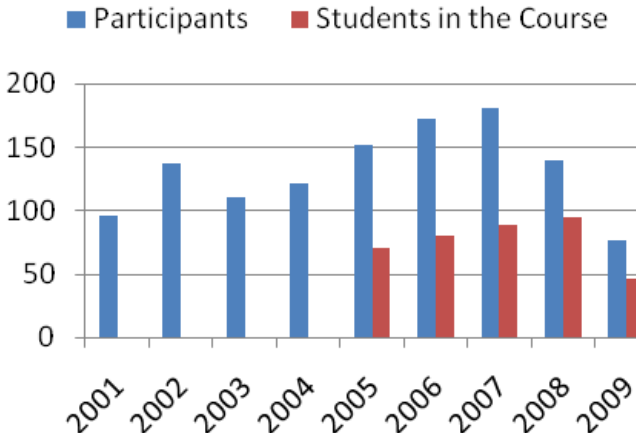

Figure 10. Number of Participant in Cybertech.

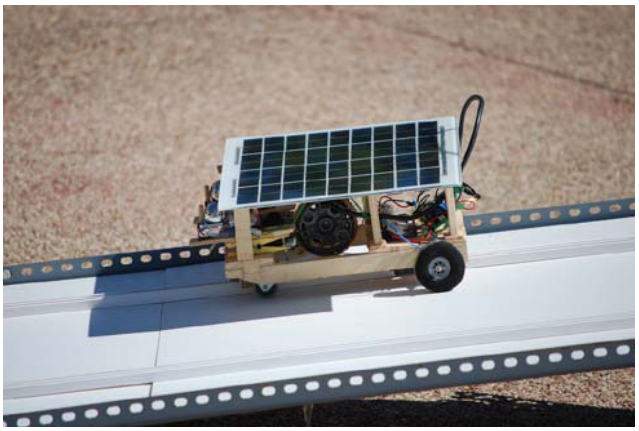

Figure 11. Solar Robot.

During 2009, for reasons beyond the organization responsibility, it was impossible to organize the contest until January so the amount of participants decreased considerably due to the few time to register.

The number of participants showed in Fig. 10 means that Cybertech is one of the most crowded subjects in Universidad Politecnica de Madrid. Every year there are more students from different faculties interested in participating and lately other universities from Spain has asked if it is possible for them to take part in the contest.

VII. UPCOMING EDITIONS

Right now Cybertech is preparing the 2010 contest and subject. On its tenth birthday the organization is willing to introduce several changes that will improve both the subject and the contest.

First of all, we are planning on an inheritance program so the teams that year after year participate in the contest will change the older members with new students. These teams are normally groups of people that registered in the subject when they were in the second degree and kept participating in the contest every year, improving their robots. It is our interest that when someone in the team refuses to participate in the next edition, the team can choose between several young applicants the new member of the group. These applicants should write a letter of motivation introducing themselves, explaining why they want to become the new team member and highlighting their skills.

On the second hand, the RoboSim event will be replaced with a Soccer League. This contest is based on the RoboCup Soccer Simulator [14] and it is intended to form groups that will be able to participate in the real RoboCup contest.

The reason why Cybertech is taking this decision is that we want it to be not only a Universidad Politecnica de Madrid contest, but a way to get to the big robot competitions that are held over the world as seen on section I.

VIII. CONCLUSIONS

Cybertech is a great opportunity for all UPM students. The participants have the chance to apply all the knowledge

Figure 12. RoboCup Soccer Simulator. [13]

acquired in their studies and to learn things that only the experience can teach.

Most of the participants undertake this kind of project for the first time in their lives and learn the importance of coordination between the team members, as good as to research solutions for real problems.

From 2010, the students that choose to participate in the Soccer League will probably have the opportunity to attend to the real RoboCup competition, as long as they prove their programs to be good enough for the contest. This is a great opportunity that will surely become Cybertech's best appeal.

Cybertech is also a chance for the students in the organization to learn several administrative tasks like how to organize a coursework. They also learn how important it is to obtain the funds needed to organize the events.

In future editions of the contest, it is possible that there will be an international event. It is the organization will to have a contest with as many foreign universities as possible participating in the bull fighter's arena.

ACKNOWLEDGEMENT

Cybertech has been funded by Sociedad de Amigos de la Escuela, Universidad Politécnica de Madrid and Caja de Ingenieros. The organization wants to thank their support.

REFERENCES

[1] Y. Zhang, C. Wu, H. Chu, Z. Jia, "Innovation Quality Cultivation of College Students by Scientific Contest" in *Education Technology and Computer Science*, vol. 3, 2009, pp. 515-518.

[2] J. P. Mendoza, F.J.R. Sanchez, "Robot Contest as an element of motivation and professional improvement in students" in *Proc. 36th Frontiers in Education Conference*, 2006, pp. 9-10.

[3] J. Pastor, J.Gonzalez, F.J. Rodriguez, "Participating in an international robot contest as a way to develop professional skills in engineering students" in *Proc. Frontiers in Education Conference*, 2008, pp. S3F-9-14.

[4] D. J. Pack, R. Avanzato, D.J. Ahlgren, I.M. Verner, "Fire-Fighting mobile robotics and interdisciplinary design-comparative perspectives" in *IEEE Transactions on Education*, vol. 47, 2004, pp. 369-376.

[5] H. Kitano, S. Suzuki, J. Akita. "RoboCup Jr.: RoboCup for edutainment" in *Proc. IEEE International Conference on Robotics and Automation (ICRA'00)*, vol. 1, 2000, pp. 807-812.

[6] J. Pastor Mendoza, "ALCABOT-HISPABOT Autonomous Robot Competition in Spain", in *Proc. 1st International Workshop on Educational Robotics*, 2006.

[7] J. Akita, H. Kitano, "RoboCup for science and engineering education: a case of the Future University – Hakodate" in *Proc. IEEE International Conference on Systems, Man and Cybernetics*, vol. 6, 1999, pp. 734-738.

[8] H. Kitano, S. Tadokoro, K. Osuka, "RoboCup Rescue project: challenges and benchmark", in *Proc. IEEE/RSJ International Conference on Intelligent Robots and Systems*, vol. 3, 2000, pp 1886-1893.

[9] I. Lafoz, A. Mora, D. Rodriguez-Losada, M. Hernando, A. Barrientos, "Behaviour control architecture for a life-like creature: the robotaurus" in *Proc. 11th IEEE International Workshop on Robot and Human Interactive Communication*, 2002, pp. 542-547.

[10] *Arduino Duemilanove Specifications*, Available: http://www.arduino.cc/

[11] *Arduino Motor Shield*, Available: http://blushingboy.net/p/motorShieldV3/

[12] *Board of European Students of Technology*, Available: http://www.best.eu.org/

[13] *RoboCup Graz 2009*. Available http://kickofftug.tugraz.at/jcms/

[14] *RoboCup Soccer Simulator*. Available: http://sourceforge.net/apps/mediawiki/sserver/index.php?title=Main_Page#The_RoboCup_Soccer_Simulator