Cybertech Robotic Competition

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Abstract. *Cybertech* is a robotic competition organized yearly by the Universidad Politécnica de Madrid (UPM) in which undergraduate students design and build mobile robots that can compete in different events. Students from UPM can follow a related course in which they learn how to build a robot. Marks obtained in the course depend partially on the results obtained in the competition. The characteristic event of the competition is the *bullfighting* in which each team must build a bullfighter robot that shows its skills against a bull robot provided by the organization.

1 Introduction

Robotic competitions in which students design, build and test a robot to compete against other machines demonstrating its abilities, are widely spread around the world. They provide many benefits to undergraduate students in terms of both learning and increasing motivation towards engineering, as it is shown in [1,2,3,4,5,6]. Students have to deal with real world problems, building a device that must work fulfilling the specifications given in the rules. They must face the different stages of engineering (requirements analysis, design, verification and redesign) while constraining to budget and time limitations. In addition they have to integrate interdisciplinary skills from mechanics, electronics and computer science, and learn how to work in teams.

There are dozens of different competitions; some of them oriented towards pushing new research frontiers, like *Urban Search and Rescue* competitions [7] and robot soccer competitions [8], while others like *Firefighting Robot* [9], *Robocup Junior* [4], *Micromouse Contest* [10], *Eurobot* [11] and *Hispabot* [12] are more focused on teaching and education. Both types of competitions attract potential students to engineering degrees.

Cybertech is a competition organized yearly by the Universidad Politécnica de Madrid (UPM) open to universities all around the world, where undergraduate students work in teams to design and build a robot that participates in different events. The aim is to attract the interest of the students while they discover the problems arisen from real applications and learn how to work in teams. Students participating in the competition can follow a course where they are taught some of the basics to develop their robots. They are graded partially taking into account the results obtained in the competition.

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The competition is described in Sec. 2, while the related course is explained in Sec. 3. An international course and competition held in 2008 is described in Sec. 4. Results and conclusions can be found in Sec. 5.

2 The Competition

The competition consists of several independent events, that have evolved over the different editions. *Maze* event, *Line-following*, event, *Solar Cars* event, *Simulated Robots* event and *Bullfighting* event took place during the last 2007 edition.

2.1 Maze Event

Maze event, as well as *Line-following* event, are held in every edition of the competition since they allow novice students to learn the basics of mobile robotics and mechatronics, allowing them to move to more difficult events when they are more experienced. *Maze* event is similar to the *Micromouse Contest* [10], where robots have to get out of a maze in a minimum time. The maze has an entrance where the robot starts and an exit to reach. Each robot has to travel through the maze in the minimum time. The maze is changed in each one of the different rounds. A picture of a robot inside the maze can be seen in Fig. 1.

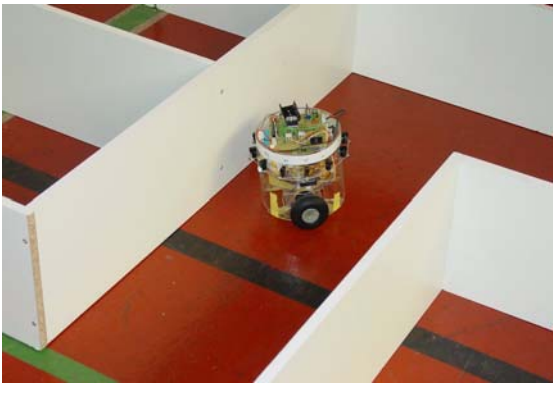


Fig. 1. The maze event

2.2 Line Following Event

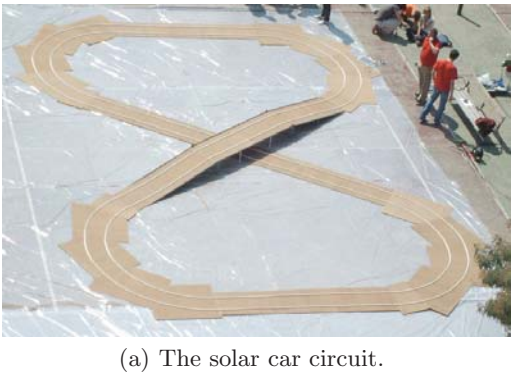
In the *Line-following* event robots must follow a black line over a white background. The difficulty is increased with the different rounds by introducing bifurcations in the path and obstacles that must be avoided by losing the line during few centimeters, to get back to it later. In addition, in some rounds two or more robots can follow one line at the same time, being the second robot forced to overtake the first in order to win. Thanks to the increasing difficulty of the event,

Fig. 2. The line following event

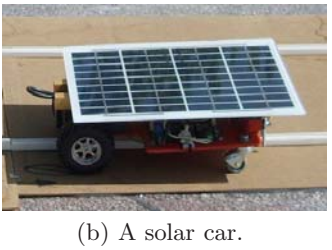
experienced and beginner participants can compete at the same time. Placing more difficult tasks in the last rounds makes best robots get better rankings. Overtakings and obstacles also make the event appealing for the public since there are more interaction between the robots. In Fig. 2 a picture of one of the line-following races with an obstacle in the field can be seen.

2.3 Solar Cars Event

Solar Cars event expects students to be concerned about new sources of energy at the same time they learn about electronics. They have to build an autonomous device that should be able to move inside a circuit being propelled just by solar energy, without possibility of accumulating it. The solar panel is provided by the organization and the students have to build the mechanics and the electronics to convert the energy. The solar car circuit can be seen in Fig. 3(a), while a solar robots is shown in Fig 3(b).



(a) The solar car circuit.



(b) A solar car.

Fig. 3. The solar cars event

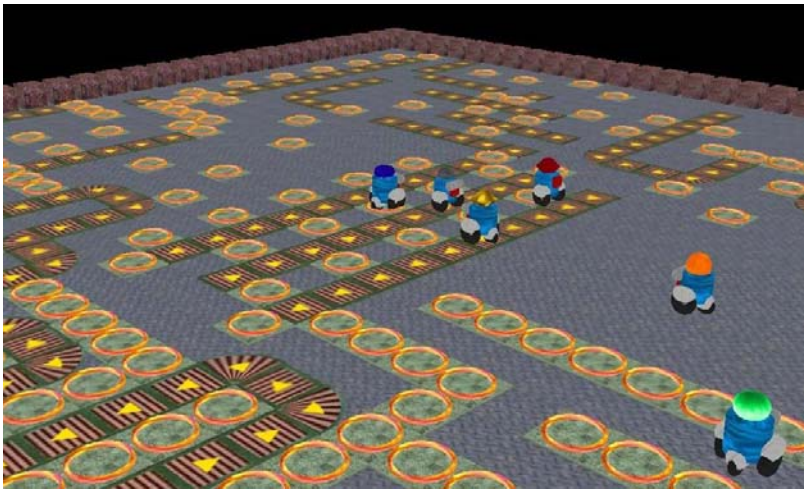


Fig. 4. The simulated robots event

2.4 Simulated Robots Event

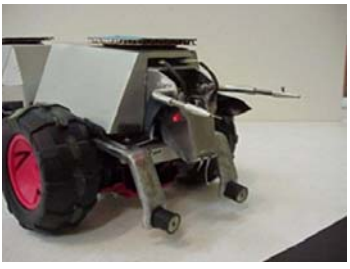
In the *Simulated Robots* event participants have to develop a computer program to control a virtual robot that moves in a simulated maze. Robots must interact between them avoiding to fall into traps; their goal is to find the way out of the maze. This event is not a multidisciplinary one in the sense that students just need to program, but on the other hand, it allows to develop more complicate algorithms. A screenshot of the simulated environment and few robots competing is shown in Fig. 4.

2.5 Bullfighting Event

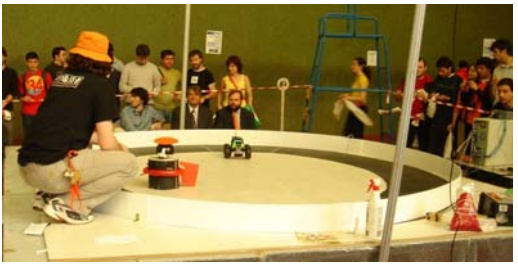
The main event that makes the competition unique is the *Bullfighting*. Each team has to build a bullfighter robot that fights in the arena against a bull robot provided by the organization. The bullfighter robot must show its bullfighting skills surviving to the bull robot attacks.

Each bullfighter robot must wear a red balloon attached around its body at a certain known height. The bull robot has sharp horns in the front part used to prick the bullfighter balloon. The most basic behavior of the bull robot is to pursue and attack red things in motion. The bullfighter robot is considered to be dead when the balloon is pricked, so its main mission is to keep it safe. It must be autonomous, all sensors and processing must be inside the robot, except the information about the positions of the robots, provided by the organization and received by a radio link. Each robot can carry a red cape outside its body in order to cheat the bull robot and make it follow the cape, avoiding to be injured.

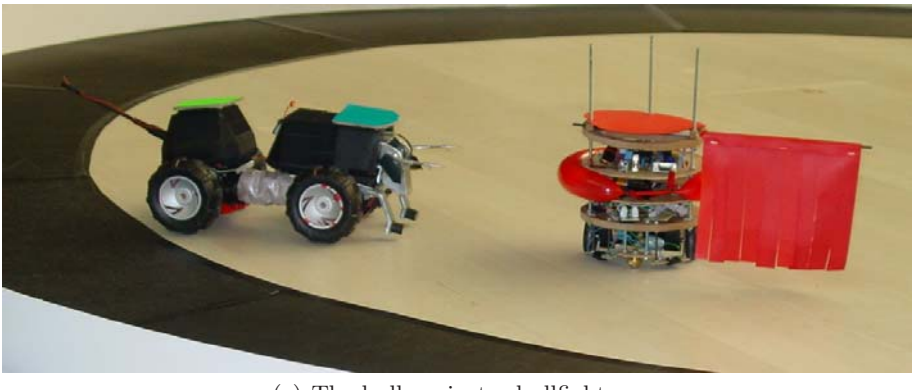
The arena where the robots fight consists of a circle of 4 m diameter surrounded by a wall of 20 cm height. The surface is divided in an inner white



(a) The bull robot.



(b) The bullfighting arena.



(c) The bull against a bullfighter.

Fig. 5. The bullfighting event

circle of 3 m diameter and a black external ring of 50 cm wide. The bullfighter robot should carry out its movements on the white circle, remaining unevaluated any action carried out over the black zone. In Fig. 5, a picture of the arena with the robots, a picture of the bull robot and a picture of a bullfight are shown.

An overhead camera is placed over the arena looking at it and connected to a computer that tracks the positions of both robots. This information is used by the computer to control the actions of the bull robot, taking into account the positions of both robots and the elapsed time. The longer time the bullfighter robot survives on the arena, the more aggressive the bull robot becomes. The computer sends the motor commands to the bull robot using a radio link. In addition, the information about the positions of both robots is sent to the bullfighter robot that can make use of it. More technical details about the implementation of this system and about the behavior of the bull robot are explained in [13].

Bullfighter robots face the bull robot one by one, getting a score that depends on the time they stay alive on the arena, this is the time they keep the red balloon safe, and on the difficulty of the movements around the bull robot they make. This last part of the score is subjective and so, given by a panel composed of three professors. Their decision depends on how many times the bullfighting robot passes in front of the bull robot, and how close it does, considering also

the reactions of the audience as it is done in a real bullfight. A better score is obtained by doing a good use of the cape, making the bull robot to pass under it. No score will be obtained if the bullfighter robot escapes all the time from the bull robot and does not approach it.

Each one of the robots shows its abilities in four different rounds of maximum 3 minutes. The winner of the competition is the one that obtains more points adding the scores of the best 3 rounds. In each round the bullfighter robot gets 1 point for every 10 seconds that it remains on the arena without being injured, and 10 extra points if it is able to stay without being injured the whole 3 minutes. The panel gives between 0 and 20 additional points per round to the bullfighter according to the bullfighting abilities shown.

2.6 Bullfighting Event Rules

The rules of the *Bullfighting* event are presented in the following paragraphs.

Article 1. Aim: The aim of the contest is to show the skill of an autonomous robot behaving as a bullfighter robot. Each team must design, build and program the robot.

Article 2. Teams: Teams must be formed by three or four students.

Article 3. Rules: These rules are fundamental and must be obeyed.

Article 4. Change in Rules: Any changes of these rules can be made by the Organization. Any modification will be communicated to the teams.

Article 5. The Judges: The judges will be in charge of taking any decision during the competition related to disqualifications, winners, etc.

Article 6. Robot Size: The maximum width and length of the robot are 30 by 30 cm. In addition its height can not exceed 40 cm.

Article 7. Robot Weight: The maximum allowed weight of the robot is 4 Kg.

Article 8. Autonomy: The robot must be fully autonomous. Sensors, actuators, energy and processing must be incorporated inside the robot. Just information provided by the overhead camera of the arena will be provided from outside.

Article 9. The Red Balloon: The robot will carry a red balloon around its body, which will be pricked by the horns of the bull robot. The bullfighter robot must have a specific area, where the red balloon will be placed, with the following characteristics:

- It will cover the whole perimeter of the bullfighter robot.
- It will be a strip of 8cm placed at a height 12 cm.
- It will not be allowed to carry any protection that will make more difficult to prick the balloon.

Article 10. The Red Cape: Every robot might carry a red *"capote"* (cape) whose aim is to make the bull go against it and not against the robot.

Article 11. The Horns: When behaving as a bull, the robot will carry horns to prick the opponent's red balloon.

Article 12. The Arena: The arena will consist of a circular area of 3 m of diameter. This area will be formed by an inner white circle of 2 m diameter, with a black ring 50 cm wide around it.

Article 13. Wall: There will be a white wall 25 cm high around the arena that will help the robots to locate themselves and avoid getting out of the arena.

Article 14. Illumination: The arena will be illuminated with artificial light, which will be as homogeneous as possible.

Article 15. Aim: The aim of the bullfighter robot is to stay as much time as possible on the arena without being injured by the bull robot. The bullfighter robot will be considered *dead* when the red balloon attached to it is pricked.

In addition, the bullfighter robot should show its abilities and skills on the arena, using its cape and making the bull robot turn around it while not being injured.

The aim of the bull robot is to find the bullfighting robot and prick its balloon.

Article 16. Rounds: Each match will consist of four different rounds of maximum 3 minutes in which two teams fight against each other. The winner of the competition will be the one that will get more points adding the scores of the best 3 rounds.

If two teams draw, the fourth round will be taken into account. If there is still a draw a fifth round will be done.

Article 17. Scores: Both the time that the bull fighter robot is able to stay on the arena without its balloon being pricked and its bullfighting skills, will be taken into account to calculate the score.

The bullfighter robot will get points as follows:

- The bullfighter robot will get 1 point for every 10 seconds that it remains on the arena without being injured (the red balloon is not pricked).
- Additionally, if the robot is able to stay without being injured the whole 3 minutes, it will get 10 additional points.
- According to the ability and skills bullfighting, the judge will give the bullfighter between 0 and 20 additional points per round.

3 The Related Course

An undergraduate course related to the competition has been offered to UPM students since 2005. The main objective of the course is that students learn how

to design and build an autonomous robot following a set of specifications. In fact students have to present a working robot at least at one of the events of the competition.

The lessons of the course consist of five thematic workshops where students learn the basics of mechatronics and mobile robotics. The first workshop is dedicated to soldering the main control board, and understanding its different hardware subsystems. During the second one they learn how the microcontroller works and how to program it. In the third workshop, the basics of motor control, and mobile robot kinematics are explained. The different type of sensors and their processing are taught during the fourth workshop. The architectures for the control of mobile robots are explained in the last session. Two pictures of the lessons can be seen in Fig. 6.

These lessons are taught by professors but also by undergraduate and Ph.D. students that have experience in mechatronics and *Cybertech* competition. The previous experience of these students helps a lot while teaching their university mates, since they know those small but important problems concerning a competition like this one.

The control board used is common to every student, and is provided by the UPM without any cost for the students. It is similar to the electronics described in [14]. In addition students have a small budget, also provided by the UPM to buy the different sensors, and actuators that they might need. This material is shared by each group made up by 4 students that compete together.

Each year the course is complemented with three speeches about a common topic, given by relevant authorities. The topic was field robotics in 2005, artificial intelligence in 2006 and climate change and solar energy in 2007. The reason for 2007 topic was the introduction of the *Solar Cars* event.

The final marks are calculated taking into account the following issues: the quality of the project developed, explained on a short paper; an oral examination

(a) A lesson.

(b) Working with the control board.

Fig. 6. The related course

on the previous day to the competition, where students explain how the robot works and show it; and the final ranking in the competition.

4 The International Course

The main novelty for the 2008 edition was the inclusion of a parallel international course and competition on mobile robotics. The course was self-contained and students with basic knowledge on computer science, electronics and/or mechanics built and programmed a mobile robot using a commercial kit. The course finished with a small competition between the different teams, consisting of a simplified version of the *Bullfighting* event.

This course was organized in collaboration with BEST, a non-profit organization aiming to internationalize students of technology via complementary education abroad. Forty students from twenty different European countries visited Madrid for one complete week, to follow the course and participate in the competition while learning about the different European cultures.

The forty students were split into ten groups of four students. Each group had different nationalities and background skills. First day, the students were given basic notions and ideas about mobile robotics and mechatronics. In addition, they built the robots using the commercial kits and performed some software tests using basic examples. Second day, the teams prepared their strategies for the competition and designed the modifications in the mechanical structure of the robots. Third and forth days were spent implementing and testing the algorithms for the *Bullfighting* event. Fifth day the competition took place. An image of a bullfight and teh robots used in the international course can be seen in Fig. 7.

The results of the competition were highly satisfactory. The robots of the ten teams worked properly, being able to show their bullfighting skills and scape from the bull robot. It was quite impressive since students only had one week to build and program the robot.

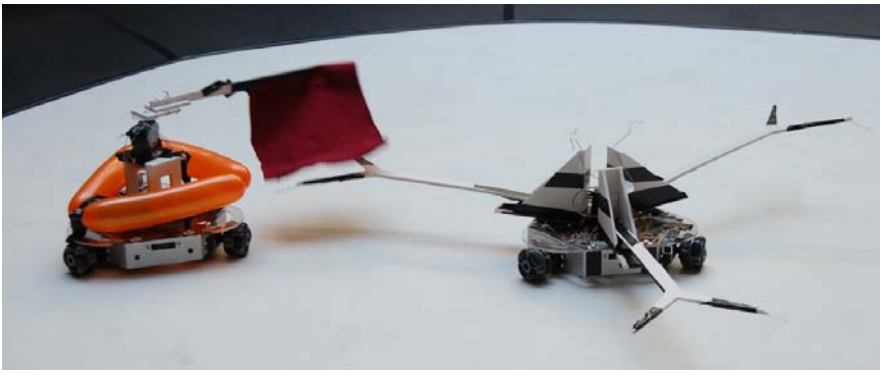


Fig. 7. A bullfight during the competition of the international course

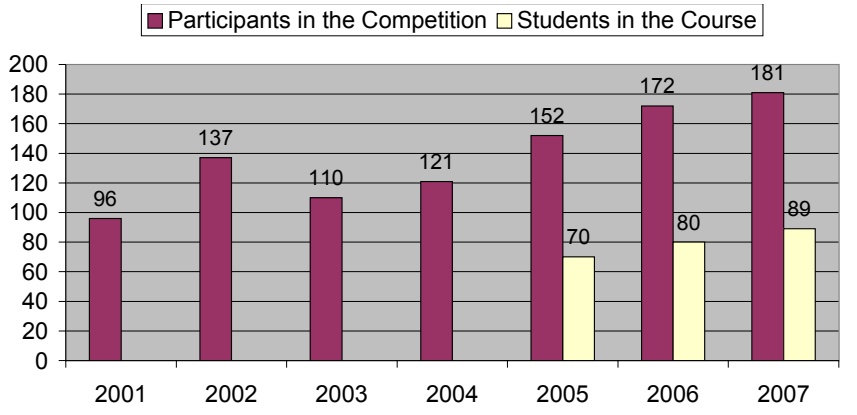


Fig. 8. Participation in the competition and in the course

5 Results and Conclusions

Cybertech competition has been a success since the beginning. It has been held yearly since 2001 with an increasing participation, starting with 96 students in the first year and having 181 in the last edition, that took place in 2007. *Cybertech* course started in 2005, when 70 students followed it, increasing up to 89 during the last 2007 edition. In Fig 8, a bar chart summarizing the participation over the editions is presented.

The quality of the robots presented has increased over the years, and it has been necessary to modify the rules of some of the events to make them more difficult and attractive. This is the case of the *Line-following* event, where obstacles and overtaking were not present in first editions. However, given the structure of the event, inexperienced students can also participate.

The inclusion of the course was one of the reasons of the improvements in the robots, and a big motivation for the students to get involved on robotics and on the competition. In addition, many students that take part in the competition write their master thesis at the Automation Department, where the competition is organized.

Every year high-school students are invited to watch the competition. Thus, students get more interested in technology and get to know the UPM, becoming potential students.

Both Cybertech Competition and Cybertech course have been a succes yearly: from the point of view of the robots presented and the organization. The competition has been always carried out during the days given and following the expected schedule.

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