Climbing Robot Competition experience at University of Catania

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Abstract

Robotic competitions are spreading all over the world for their importance in attracting students and disseminating the use of new technologies. The spirit of these competitions is to direct students towards science and technology and at the same time to entertain. The robotic group of the University of Catania found very useful this kind of events and, every year, involves small groups of students, providing them only the basic concepts and logistic support, without directly managing the team. The final results are that students learn faster basic theoretical concept of robotics and solve practical problems while enhance their capability to organize a work-group.

1. INTRODUCTION

One of the two main competitions that are encouraged at the University of Catania is the Eurobot, that is mainly addressed to young students from engineering schools, universities and private scientific clubs. The rules of this competition are generally very simple and change every year. This choice allows new team to enter the competition without the needs of previous year expertise and to have all the teams at the same level each year.

The other competition is the CLAWAR Climbing Robot Competition that has been organized each year since 2000 during the CLAWAR Conference. CLAWAR [1] is a network between universities, research centres and industries that operate all around Europe. In Figure 1 and Figure 2 the Network logo and the Climbing Robot Competition logo are shown. The aim of the network is to share industries needs and research knowledge. This competition is addressed not only to students but also to research groups from many different areas and countries. The rules, very flexible, are always the same: to design a robot that is able to climb a flat vertical wall (magnetic or non-magnetic) avoiding obstacles in the path. Every year the University of Catania, one of the CLAWAR Network partner, has presented a different climbing machine that was able to deal with specific competition tasks.

In this paper a description of the different machines, rules, some result and human/educational aspect will be outlined.

2. CLAWAR COMPETITION RULES

The target of each machine that would attend to the competition should be to climb a vertical wall, avoiding randomly placed obstacles and reach the upper part of the wall. The climbing robot should be autonomous, carry the appropriate sensors and locomotion control systems on-board and implement some obstacle avoidance technique and navigation algorithm. The autonomy requirement does not necessarily implies that the power supply must be on-board. The robot can be fully autonomous (on-board control and power supply) or can have external power supply and/or control. Four tasks are defined and each robot has to cope at least with one of this.

- **Task 1**: To simply climb the vertical surface starting from the bottom with no regards for the initial machine orientation and to reach the top with no obstacles or barriers.

- **Task 2**: To climb the vertical surface starting from the bottom with no regards for the initial machine orientation and to reach the top with randomly placed obstacles on the wall.
- **Task 3**: To climb the vertical surface starting from the bottom with no regards for the initial machine orientation and to reach the top. Machines must successfully negotiate a small barrier (1cm high, 1cm wide) that is designed to obstruct the vehicle's progress up the wall.
- **Task 4**: To start on the horizontal plane, transfer itself onto the vertical surface and then proceed to climb the wall.

Figure 1. CLAWAR Network logo

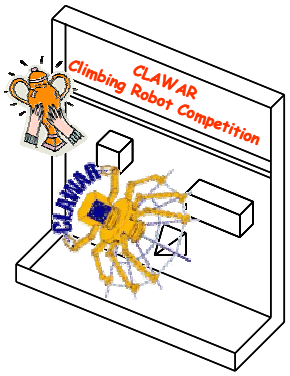

Figure 2. CLAWAR Climbing Robot Competition logo

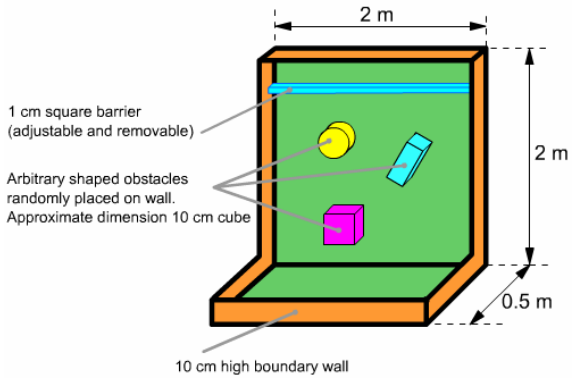

Figure 3. A sketch of the wall used during the competition

The dimensions of the walls (see Figure 3) are about 2m X 2m and a typical obstacle is about $10cm^3$ in size with various shapes. The wall is made of ferrous metal sheets to accommodate magnetic adhesion, but it is also flat and smooth enough to also allow for suction attachment. It is made of metal sheet approximately 3mm in thickness and with vertical joints between the panels that compose the wall. The colour of the wall is black. The wall has white metal side panels, 10cm height, to stop the robots falling off. Obstacles are made with white wood. The little barrier is wood-made and white in colour. Its size is 1cm X 1cm X 2m. In any case the robots should not exceed 30 cm in size because this is the typical gap between obstacles.

A panel of experts carry out the judging of the competition, to award points to each robot, and ultimately the prizes to the winning designers. They have to be both impartial and fair, allowing all entrants the opportunity to demonstrate fully all the features of their machines, but demonstration time for each machine is limited and selected at the judges' discretion. Each individual robot accumulates points based upon a set of criteria, and also upon which of the tasks are attempted. The tasks have each been assigned a certain 'weighting', which will be taken into consideration when allocating points to individual machines. This is because they progressively pose increasing levels of difficulty to the machine developers. The judge decisions are based upon the following categories as a basis for allocating credits to each individual machine.

- Novelty
- Easy to use
- Level of autonomy/intelligence
- Speed / time of ascent
- Versatility - Capability to complete several tasks
- Simplicity of concept - for commercial manufacture

3. THE 2000 COMPETITION

During the 3rd Clawar Conference (Madrid - Spain), the first Climbing Robot Competition was organized. The University of Catania participated presenting a very 'strange' robot; in fact, in contrast to the Clawar rules, the presented system can only climb-down the wall but not climb-up. The robot SCID (Sliding Climbing Inspection Device) shown in Figure 4, does not use any actuators; it only uses two electromagnets connected to the structure via two rotational joints and uses the gravity force to slide down. By attaching one electromagnet to the vertical wall and by controlling the friction of the other one with respect to the wall, the robot can follow a downwards path (Figure 5). It is equipped with a ST5 embedded microcontroller, an inclinometer and two potentiometers as feedback element.

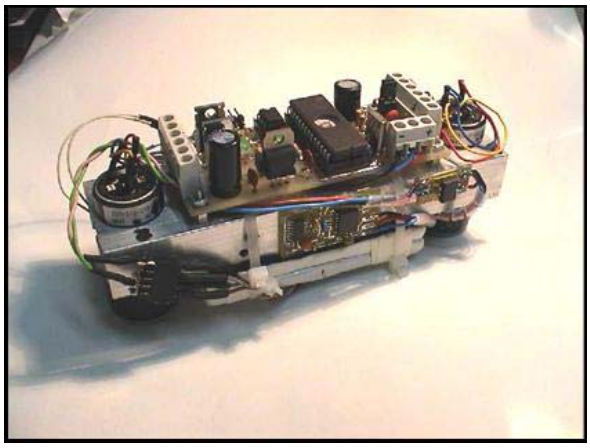

Figure 4. The SCID climbing robot

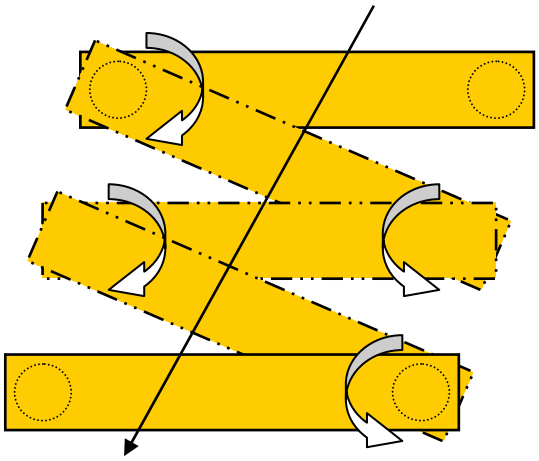

Figure 5. Typical trajectory of the SCID robot

This edition of the Climbing Robot Competition has to be considered as a tentative, so all the participants won. The Catania team was composed by one student from the Industrial Robotic course at University of Catania.

4. THE 2001 COMPETITION

The 4th Clawar conference was organized in Karlsruhe - Germany. The robot presented from University of Catania to that competition is named "Alicia Prototype" and is shown in Figure 6. It is very simple and very low cost one. It uses a single large suction cup with onboard air pump to adhere to various types of clean non porous surfaces. A ST5 embedded microcontroller is used to pilot two modified servo motor with wheels for locomotion and to acquire the inclinometer and the IR measurements. The infrared sensors are used to avoid obstacles that the robot can find on the path in front of it, while the inclinometer measures the orientation of the system. The system can start from any orientation and can reach the upper part of the wall.

The robot won a cash prize and the team was composed by another student from the Industrial Robotic course.

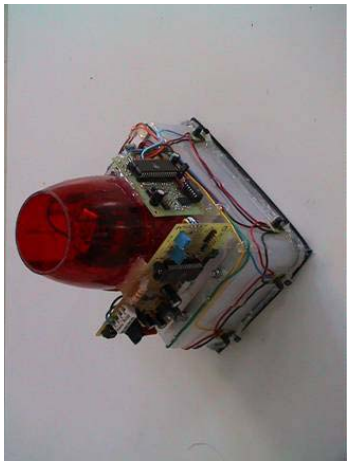

Figure 6. The Alicia prototype

5. THE 2002 COMPETITION

The 3rd Clawar Climbing Robot Competition was carried out in Paris (France) during the 5th Clawar Conference. The new robot presented (Alicia I) was a very simple evolution of the first prototype, even if it may seem very different because of the suction cup has been entirely redesigned, the wheels have been placed outside the suction cup to increase their distance and different kind of IR sensors were adopted for the obstacle avoidance. Moreover the use of a crossed IR sensors disposition (Figure 8), gave the best obstacle avoidance behaviours; indeed, the traditional orthogonal disposition could bring to unseen obstacles. The navigation algorithm, consider different weights for each sensor to understand the obstacles position.

Alicia I was the winner of this competition. The student that carried out this project, has continued this work for his thesis; the Alicia I robot is a very simple structure with big potential, but has limited capabilities when obstacles higher than 1 cm are on the wall and with big payload. For this reason, inspired from Alicia I experience, two new professional robots called Alicia II and Alicia^3 have been realized as PhD thesis of the student that participated during the first two editions.

The Alicia^3 robot [2] [3] is a modular system with three suction cups (Alicia II module), each with two actuated wheels. The three suction cups are linked together and actuated with two pneumatic pistons. The Alicia II robot can be a fully autonomous one.

Figure 7. The Alicia I robot in Paris

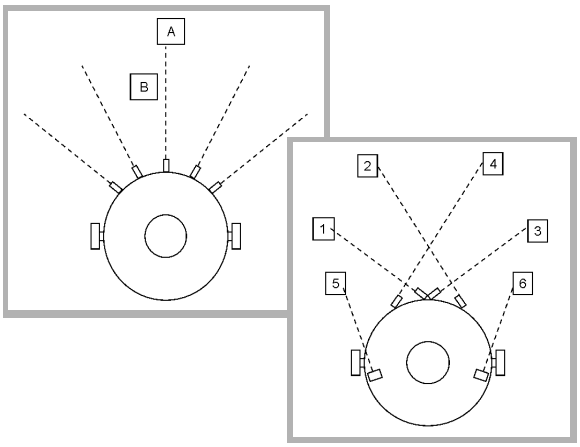

Figure 8. The traditional and new IR sensor scheme

6. THE 2003 COMPETITION

In 2003 the 6th Clawar conference was held in Catania (Italy). Two teams from Catania participated to the competition: Alicia I, the same robot that participated the year before, with minor review and a new robot named Abran. This robot was realized starting from the commercial platform BoeBot based on a Basic Stamp microcontroller board. Two strong magnets were mounted under the chassis in order to have the necessary attraction with the vertical wall. The system was a dual drive, actuated with two modified servomotors and also had an inclinometer and some IR sensors to estimate the obstacles positions. Also in the 2003 edition Alicia I was the winner. The first prize was an AIBO robot offered by SONY.

Figure 9. The Abran robot

7. THE 2004 COMPETITION

The fifth Clawar competition was organized during the 2004 Clawar conference in Madrid (Spain). A new robot named "Venom" was designed with a completely new structure. Some magnets for the attraction, a pair of servomotors and a dual drive system for the locomotion, a inclinometer and some IR sensors for navigation and obstacles avoidance. A ST10 microcontroller was adopted to pilot the robot and to decode the signals of a modified optical mouse used for localization. In this edition Venom reached the second position at the competition.

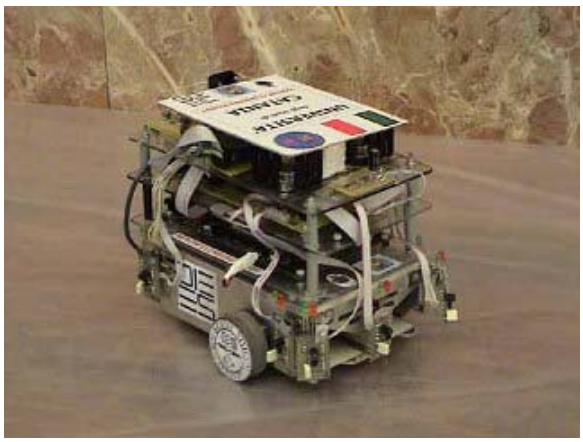

Figure 10. The Venom robot

8. THE 2005 COMPETITION

The competition of this year will be held during the Clawar 2005 Conference that will be organised by the Department of Automatic Control and Systems Engineering of the University of Sheffield. The venue for the conference will be London – UK from 13 to 15 september 2005. All the people that would to attend the competition must register within specific time that will appear on the Conference web site. Each team have to pay a registration fee, moreover each team will be expected to provide information on themselves, robot and organisation. They would also be expected to produce a small poster to be presented during the Conference. A booklet with a list of sponsors, prizes and a description and photo of each team and their robot will be produced. A forum for the competitors and a FAQ list will be available in the Conference web site. For further information about the competition, please contact Domenico Longo (dlongo@diees.unict.it) or visit the conference Web Site: http://www.clawar.net/clawar2005/.

4. CONCLUSION

The design of all of the robot presented in this paper was a very important experience for all the students that participated to the competitions. To design a robot simply starting from their ideas is a very important experience for the students. They have to learn to work in a group, to respect deadlines to complete their design with a given budget, to understand how to solve real engineering design problems. Moreover the possibility to compare their robots with the designs of other students is a really important educational experience. The spirit of competition and the impulse given from the presentation of the robot to the public is also a very important stimulating factor for all the teams to increase the reliability of the systems.
The experience gained is fundamental and many of the students that were "trained" by the competitions have been subsequently involved into different research projects, for the design and built of service robots. Some of these students have continued their studies toward a PhD and many of them are now professional engineer that remember their participation to the competitions as a fundamental experience in their curriculum. Moreover these competitions, both from the students and for the teachers' points of view, represent a very good opportunity to learn and have fun at the same time!

Figure 11. The Venom robot team

Figure 12. The 2002 edition teams

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