How contests can foster the research activities on robotics in developing countries: Chile a case study

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Abstract. The aim of this article is to describe our experience in the participation and organization of robot contests, and to show how these actions have increased the activities on robotics in Chile. We describe the annual Latin American IEEE Robotics Competition, we present the IEEE Latin American Robotics Council, we explain our participation in RoboCup, and we present our activities concerning robotic courses for children.

1. Introduction

The purpose of RoboCup and in general of robot contests is to foster the activities on robotics and to push the field and inspire future research. The aim of this article is to describe our experience in the participation and organization of robot contests, to show how these actions have increased the activities on robotics in Chile, and finally to give our view about the effect of this kind of activities. We believe that our experience can be useful for other developing countries.

In this article we first show the current state of the robotics field in Chile and we contrast it against the current state of other disciplines (section 2). For doing that we carried out an extensive research study, which considered investigation on Internet, on public paper databases, on national science databases, as well as direct contact with the researchers. We show that the robotics field is underdeveloped in our country, and that its development degree is low compared with other research fields.

Afterwards we show how robot contests in general, and RoboCup in particular, can help in reverting this situation. In section 3 we give concrete examples of that. We describe the annual Latin American IEEE Robotics Competition, we present the IEEE Latin American Robotics Council, we explain our participation in RoboCup, we present our activities concerning robotic courses for children, and finally we show how all these activities have largely increased not only our own activities in the field, but also the activities on robotics in Chile and Latin America.

We consider that the development of robotics is important not only by its own, but also because it serves as a motivation to work in related technologies as sensoric, electronics, power systems, signal processing, automatic control, intelligent systems, software agents, just to mention a few.

Finally, in section 4 some conclusions of this work are given.

2. Problem Definition

2.1 Research in Chile

The state of research in science and technology in Chile will be analyzed on hand of the number of papers produced by researchers working in Chile, the impact of these papers, as well as indicators of the local technological development (e.g. patents

indices). The main information source will be CONICYT, the National Chilean Council of Science and Technology [1].

Chile is a country of 15 millions inhabitants with a per capita income of US$ 4346, an alphabetization rate of 95.2% and an expenditure in R&D of US$377.2 millions (table 4.4 in [2]). There are 7.2 thousand researchers in Chile, and 22575 ISI publications were generated during period 1981-2000, the number of citations was 152070 (table 4.4 in [2]). According to CONICYT the impact index of the publications generated in Chile is 6.74, which is well compared to similar indices of Spain (6.78), Argentina (5.63), Hungary (6.57), Portugal (5.99), Mexico (5.48) and Brazil (4.99), just to show some examples (USA has the largest index: 16.34). Chile has the highest research indices in Latin America, with 11.94 ISI papers per 100 thousand inhabitants and 0.978 ISI papers per researcher (tables 4.8 and 4.9 in [2]).

However, if we look carefully on the Chilean research indices, we will notice that science is much more developed than technology. While in the period 1981-2000 only 658 ISI paper where published in engineering, 2120 were published in astrophysics and astronomy, 4079 in biology, 3138 in chemistry and 1397 in physics (table 4.1 in [2]). Moreover, if we observe the number of requested patents in Chile, an indicator of technological development, we will see that in year 2000, 407 patents were requested by Chilean residents, while 3276 were requested by non-Chilean residents (table 4.16 in [2]). The number of patents requested per every 10 thousand inhabitant is only 0.32 (table 4.20 in [2]). Just as a last fact, Chile was classified number 20 in the IMD 2002 World Competitiveness Yearbook [3], which is a very good position. However, the IMD report indicates that the main drawback of Chile in order to raise his relative position is on its low R&D indices.

As a final conclusion we can say that although sciences in Chile shows good development level, engineering and in general technology has a low development level.

2.2 Study about the state of Robotics in Chile: Methodology

The aim of our study was to determine the state of the robotics field in Chile. For doing that we required information about: (i) researchers working in robotics in Chile and their institutions, (ii) the international and national publications on the field, (iii) the research projects, and (iv) courses on robotics given to undergraduate and graduate students. For carrying out our study we have made the following sequential actions:

1. All main Chilean universities were asked for their activities in robotics and for the researchers working on robotics and related fields. These researchers were directly contacted by e-mail.
2. An exhaustive Internet investigation using the search engines google and todocl [4] was carried out. All Chilean sites containing the words “robot” and “robót”, which are the seeds for robotics related words in English (robot, robotic, etc.) and in Spanish (robótica, robótico, etc.), were analyzed.
3. All government-funded projects in robotics, which are listed in the databases of CONICYT, were analyzed.
4. Using the information obtained with these three described actions, a first database of researchers working on robotics in Chile was built.
5. The personal web pages of these researchers were analyzed.

5. Finally, we looked for the international papers published by these researchers, using the ISI databases [5] and "Citeseer" [6].

2.3 Study about the state of Robotics in Chile: Results

This first study about the state of robotics in Chile gives the following results:

- **International Publications**: The number of international publications on robotics is very low. Only 3 papers were published in international journals (2 of them correspond to joint collaborations with foreign institutions) [7, 8, 9] and 14 papers in international conferences. The publications were done between years 1985 and 2002. The situation is shocking. These first results clearly indicate that the field is underdeveloped in Chile and that their development degree is low in comparison with other research fields in Chile (see section 2.1).
- **National and Latin American publications**: 13 papers were published in national journals (non ISI indexed) and 53 in conferences. The publications were done between 1983 and 2002. We believe that these results show that either the level of the publications is below international standards or the researchers have no interest or no means to publish outside Chile. Even if the later is the case, the number of publications is still rather low.
- **Research Projects**: We found just 15 projects on the field between years 1987 and 2002. 7 correspond to projects of the National Fund for Science and Technology Development, FONDECYT [10], 3 correspond to projects of the Fund for Fostering Scientific and Technological Development, FONDEF [11], 2 correspond to FONDECYT-DOCTORAL projects and the last 3, to projects funded by universities. FONDECYT and FONDEF are the two main national research program from CONICYT, and according to the Chilean standards, these projects have normally a better level than projects funded by universities. However, we find a contradiction on these numbers. We have 10 (7+3) good level projects, but just 3 international journal papers and 14 international conference papers generated by them. This fact could indicate either that the projects were not successful in terms of the obtained results or that the researchers had no interest on publishing.
- **Courses**: At this moment we can find just 5 courses on robotics given by 3 Chilean universities. At the end of this year this offer will increase to 7. In two more years this number will reach to 9 courses given by 4 different universities.

By analyzing the presented results we can conclude the following:

- By all different possible measures we can affirm that the robotics field is underdeveloped in Chile. Its development degree is low compared with other research fields. Even if we think that the results of this study are not accurate and that they have a deviation of 100%, the obtained numbers are extremely poor.
- These first results contrast with our experience on which robotics generates high interest in Chilean engineering students, especially from fields like electrical and mechanical engineering, as well as computer science. Just 2 examples: (i) from 70 students entering our department this year, 31 have interest on robotics and computer vision (13 as first choice, 9 as second choice and 9 as third choice), and (ii) our robotics course, given by the first time this semester, has 25 students.
- Taking into account the number of publications, research projects, as well as courses on robotics, we can establish that four universities concentrate most of the

activities performed on the field of robotics in Chile. They are (in alphabetic order) Universidad de Chile (Dept. of E.E.), Universidad de Santiago de Chile (Depts. of Computer Science, E.E. and Industrial Eng.), Universidad Técnica Federico Santa María (Dept. of Electronics) and Pontificia Universidad Católica de Chile (Depts. of Mech. Eng. and E.E.). In this four universities no more than 10 researchers are active in the field.

2.4 Understanding this situation

Chile has a low level of industrial development and its economy is based either on the service industry (basic services, banking industry, tourism industry, etc.) or in the exploitation of natural resources (mining industry, forestry, fishing, wine industry, farming industry, etc.). Moreover, given the current per capita income, the cost of the manual labor is still low, although not as low as in south Asia or other Latin American countries. For these reasons robotics related technologies have not attracted much attention, either in industrial or educational sectors. Another factors to mention are: (i) lack of knowledge on the importance of the field and (ii) research in robotics is usually considered as extremely expensive.

However, things are changing. Chilean economy was growing at a 7% rate during the last decade, and experts say that a condition to keep this growing rate is to introduce technology in the Chilean traditional economy areas for increasing productivity and also in the manufacturing industry for improving their development. In both cases robotics related technologies can play an important role.

3. Robot contests can foster the research activities on robotics

In this section we will show how robotic contest can revert the situation described in the previous section.

3.1 Latin American IEEE Student Robotics Competitions

The first Latin American IEEE Student Robotics Competition was held last year in Chile (http://ewh.ieee.org/reg/9/robotica/1stRobotContest/). The event was organized by the Department of Electrical Engineering of the Universidad de Chile and by the IEEE Region 9. The main objective of this competition was to increase the interest of engineering students in robotics.

A second objective was to stimulate student involvement in advanced technologies and their application to practical use. The competition looked for bringing the exhilaration of scientific discovery to young students, fostering technological innovation in the graduating engineers, while providing more technical activities to local IEEE students. A robotics competition was considered an activity that could help in that direction, particularly given the success of similar events in other countries. The competition was held during period 29-30 November 2002, at the Department of Electrical Engineering, Universidad de Chile, Santiago, Chile. Two separate robot competitions took place, details are provided in Spanish in [20].

The first competition (“beginners”) was aimed for students starting to work in robotics and was based on the use of Lego MindStorms building blocks. In this category the proposed challenge was the design and programming of a robot, or

equipment of robots, that accede and cross a simulated minefield. The robot or equipment had to detect simulated, explosive charges and to avoid stepping on them in an inadvertent form. The success criterion was the number of detected mines, the time from the departure point to the term of the mission, and the number of inadvertently detonated mines (those that damage the robot).

The second competition ("advanced") was for more experienced student groups. The competition consisted in crossing a soccer field with obstacles using any kind of legged robots (biped, hexapods, etc.). Robots could be designed and constructed by the own participants, or could be bought and then adapted (mechanical modifications, new sensors, etc.). It was understood that robots should be autonomous and in no case they could be controlled, although partially, in remote form. There were no restrictions concerning the size of robots, the power source used, neither the sensors employed (infrared, ultrasonic, laser, cameras, etc.). The success criterion was the crossing time.

The first competition day was for reception of the participants and for setup of the robots. A plenary talk on robotics technology, given by a Distinguished Lecturer from the IEEE Robotics and Automation Society was also scheduled for the first day. The second day was dedicated to the contests. Both competitions were developed in parallel, although the finals of each one were scheduled at different time. Before competitions a 5 minutes presentation of each robot to the jury and the general public by the participants was considered. After the competitions there was an exhibition of all participants robots to general public, especially to school' children.

We believe that this first Latin American competition was a success. 29 groups of 4 different countries (Argentina, Chile, Mexico and Peru) participated in the contest, totaling more than 100 engineering students and 4 high school students. Considering the short preparation time (6 months) and the long distances in Latin America, this was a good starting that for sure will be improved in the next versions of the contest. During the second competition day we had more than one thousand persons attending the event. The event was also covered by almost all Chilean newspapers (see some articles in [21]) and by the most important TV station in its main news program. Media coverage was considered very important, because it promotes public awareness of the importance of technology in society.

In general terms we believe that the main result of this event is that it will foster the activities in robotics in Chile and also in Latin America. Here we mention some concrete examples:

- The institution of an annual Latin American IEEE Student Robotics Competition as a regular activity of the IEEE Region 9. The next competition will be held on Sept. 2003 in Brazil, while in 2004 it will be held in Mexico.
- The foundation of the IEEE Latin American Robotics Council in January 2003, with the long-term mission of developing IEEE activities on robotics in Latin America. A detailed explanation can be found in section 3.2.
- The institution of an annual Chilean IEEE Student Robotics Competition, which next version will be held on August 2003 at the Department of Electrical Engineering, Universidad de Chile.
- At a national level the activities on robotics, such as the creation of robotics courses and the conforming of robot research groups, have increased in the universities where students participated in the robotic contest. As an example,

based on the demands of our students we have created an introductory course on robotics, which is being given for the first time during this fall semester (March-June). During our spring semester (August-November) we will give, also for the first time, a course on mobile robotics. These two courses will be added to our related courses on mechatronics and in automatic control. Since October 2002 our "Robotics Lab" is full from students, not only from our department, but also from Computer Science and Mechanical Engineering.

- Also at national level we can see an increasing interest in similar kind of robot contests, especially on robot soccer. Recently the Pontificia Universidad Católica de Chile (Dept. of Mech. Eng.) has conformed a FIRA robot team and our department has conformed two RoboCup teams, F-180 and "Four-Legged". This activity is described in section 3.3.

3.2 IEEE Latin American Robotics Council

For giving continuity to the IEEE robot contest in Latin America in January 2003 was founded the IEEE Latin American Robotics Council [22], whose organization and operation is in charge of us. The main purpose of this council is to organize, with the support of local groups, an annual IEEE Student Robotics Competition in Latin America. The Council will promote the programming of these events, define the basis for the competitions, and interact with the local volunteers who finally will develop the activities themselves. The council will grow from this event into helping at developing more IEEE activities in robotics in Latin America.

As a first activity, the council is organizing the 2nd Latin American IEEE Student Robotics Competition (http://www.ewh.ieee.org/reg/9/robotica/2ndRobotContest/), which will be held in September 2003, in Bauru, Brazil. This competition will include beginners and advanced contests, as well as robot soccer competitions.

3.3 RoboCup Teams of the University of Chile

As a way of canalizing the increasing interest of our students on robotics activities, we decided to create two robotic soccer teams, which will participate in RoboCup, from this year on. The teams are from the small-size F180 league and from the AIBO four-legged league. In December 2002 we took that decision, in spite of we had only 7 months before RoboCup 2003 and just 4 months before the classification stage. We started from zero. We had no experience with RoboCup (no Chilean team was in RoboCup before) and we neither had all the robots.

To achieve our difficult objective we started to work in parallel, in several fronts, with a group of 35 undergraduate and graduate students. In a first stage of 'setup', one student group was in charge of the compilation of all necessary RoboCup information (official site, leagues information, rules, source codes, simulators, etc.) mainly through Internet. Another group was in charge of building the two official soccer fields, while a last group was in charge of buying the AIBO robots, and buying and adapting the robots for the F-180 league. This stage took about 25 days.

Afterward we started the second stage that consisted in the research work for writing the algorithms and designing the playing strategies for both teams. We divided our 35 students in two teams, 20 for the F-180 league and 15 for the four-

legged league. This decision was based on the fact that the F-180 league requires work in hardware and software aspects, while the four-legged not. For each robot team we defined the block diagram of the final system we wanted to implement. A group of 3 to 4 students was in charge of each one of these blocks. In each category we have a special group in charge of making simulators. Given that we have 9 groups working in parallel, organizational aspects are very important. We have a hierarchical organization of the work and meetings every two days for each team, whose main objective is to coordinate the work of the teams. A graduate student from our doctoral program on automation was in charge of each team. After months of very hard work, including holidays, we finished this second stage last March.

Since March 15 we are working on the third stage, which can be characterized as "playing, playing and playing". The aim of this stage is to increase the performance of our teams by means of intensive experimentation. In this context, we participated in the RoboCup American Open with our two teams. This stage will be finished on July 2, with the participation of our four-legged team in the RoboCup 2003.

Participating in RoboCup has been an interesting challenge for us. We built a multidisciplinary team of students, which includes students with different majors like computer science, automatic control, telecommunications, electronics, power systems, signal processing and even physics. These students have been working for free and also during their vacations time. Student holidays are from December to February in Chile and universities are closed during February. We believe that this group of students will be the basis for the consolidation of our research group on robotics. It should be stressed this is the first time that in our department 35 students are working together in a single research project.

3.4 Current Projects

Things are changing very fast in our "Robotics Lab". The lab started on May 2002 and at the moment we have two doctoral students and four master degree students doing their thesis in mobile robotics. Four more master degree students are performing their final thesis in robotic vision. At the moment we have several projects in robotics. In addition to robot soccer, we are involved in the development of robotic vision systems using robotic-heads, and in the development of a friendly robot interface that interacts with humans by detecting and recognition their faces. We are building an electronic glove for the haptic control of our robot arms, and we are developing a 1.5-meter-high mobile robot, with the final goal of installing it in an important Chilean museum.

Last but not least, thinking on the future we have been working with school' children by doing practical robotics courses. Our motivation comes from the need, especially in developing countries like ours, of motivating and foments the interest of children and young people in technology as early as possible. The participation in practical courses of robotics is a highly motivating activity, because it allows the students to approach the technology in an entertained and intuitive form. Based on that we have achieved that more than 700 children and 80 school' teachers assisted to one of our one-week robot courses. As a side effect of our courses, some Chilean schools are planning the installation of their own robotics laboratories. For more information about our activities with children, in Spanish, see http://www.robot.cl/.

4. Conclusions and projections

The main purpose of robot contests is to foster the activities on robotics and to push the field and inspire future research. The aim of this article was to describe our experience in the participation and organization of robot contests, to show how these actions have increased the activities on robotics in Chile, and finally to give our view about the effect of this kind of activities. We showed the current state of the robotics field in Chile and we contrasted it against the current state of other disciplines. Afterwards, we described some actions taken to revert the current situation: the organization of annual Latin American IEEE Robotics Competition, the creation of the IEEE Latin American Robotics Council, our participation in RoboCup, and our activities on robotics with children. After all of this we can conclude the following:

- The robotics field is underdeveloped in Chile and its development degree is very low compared with other research fields.
- Robot contests in general, and RoboCup in particular, can help in reverting this situation. The organization and the participation in robot contests have largely increase not only our own activities in the field, but also the activities on robotics in Chile and Latin America.
- Robotics related technologies could play an important role in the technological development of countries. In this context, the development of the robotics field is important not only by its own, but also as a motivation to work in related technologies.

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