

AGROTECH09: BUILDING AGRICULTURAL ROBOTS WITH LEGO MINDSTORM. A MULTIDISCIPLINARY AND MULTICULTURAL APPROACH

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Abstract

This activity has been designed in the context of an innovation project devoted to the coordination on mathematical, physical, and engineering contents for a transversal path on mechatronics, automated control and information and communication technologies (from now onwards AGROMECA TIC) at agricultural engineering studies in the Technical University of Madrid. One of the main tasks has consisted on setting up a new subject, robotics in agriculture (equivalent to 7 ECTS), which is used as a platform to test the abilities of the students to apply various aspects of the knowledge gathered along the previous 4 years on agricultural engineering, with special emphasis on.

The students are demanded to build a variety of basic mechanisms into an autonomous vehicle capable of performing user defined general and specific agricultural tasks (such as selective harvest, transport, loading and unloading of product). The robot is programmed using object oriented language (LEJOS, JAVA for LEGO) and has to cover a variety of behaviors: navigation, exploration, and previous defined agricultural tasks.

As a mean to test the skills developed by the students and to reinforce the multidisciplinary nature of AGROMECA TIC, a European contest: AGROTECH09 has been settled, which is co-organized by BEST (Board of European Students of Technology). The activity will take place between the 11th and 14th of May at ETSI Agrónomos and recognizes up to 2 ECTS of individual dedication. 40 students from 16 countries with large variability of backgrounds: computers science, agronomy, engineering, physics, tele-communication will work jointly to solve a challenge which will be public on the 11th of May with all materials being provided by the organization.

Keywords - Innovation project, robotics, international contest.

1 THE BACKGROUND [

Robotics is a developing area in agriculture. From the 80ths of previous century we have seen emerging trials applied to crop scouting, spraying, weeding, harvesting [1] yet the very specific and restrictive environmental conditions of agriculture makes the issue still a challenge.

As an emerging area, robotics is best suited for testing creative ideas which have to be integrated with well established knowledge such as mechanics, electronics, and computing. In such a sense young engineers and science students can provide a refreshing and enthusiastic point of view.

From 2000, Wageningen University established the Field Robot Event [3] which is a contest where students' teams are welcome to bring their own robotic proposals. Year by year this event has shown how to evolve towards solving more complex tasks from navigation to object identification. We wanted to start from this example but we also wanted to provide a very different way of working so that both events became complementary instead of competitors.

2 ORIGINAL IDEA

A team of professors from a variety of departments (Applied Physics, Applied Mathematics and computing, and Rural Engineering) felt the need for designing a transversal educational path which would gather optional subjects related to precision agriculture, mechatronics, automated control and information and communication technologies, so that the students became familiar with a pool of fields of knowledge which are common to most technical studies yet not the main objective for Agricultural Engineering.

In this context, there was the idea of setting up a new subject, Applied Robotics in Agriculture which would try to integrate and test how deeply the students had assimilated the AGROMEATIC concepts. This subject would need an intense all year through dedication (equivalent to 7 ECTS, 190 h) but also an adequate platform to work with which had to fulfill several conditions such as ready to use and flexible material: Lego Mindstorm NXT Lego Mindstorm is being used in different educational experiences [].

Moreover, the above mentioned pool of professors decided that it could be interesting also to setup a multicultural activity where our students could share and compare their own skills with regard to all throughout European students, and which would also account for the effort in terms of European credits (2 ECTS, 54h).

3 INITIAL STEPS AND ORGANIZATION

When trying to organize a new international event, there is a need to address the proper environment to call for participants. In this sense, BEST (Board of European Students of Technology) showed to be the best network solution with enthusiastic and well prepared team of people. The professors from AGROMEATIC were happy to find a good reception of the idea by BEST Madrid. The students' organization promoted the proposal to their International Steering Committee in October 2008 being finally lunched in November that year.

Besides, AGROMEATIC decided to apply for founding in the framework of an innovation project in education at UPM which succeed. This project enabled to provide the basic material for the subject development and event in terms of Lego Mindstorm units (30 robotic boxes plus 30 units for gears and building assemblies), as well as four student grants for assistance to this new issue. The Direction of the School of Agriculture turned out to be happy to host such initiative not just as stand-alone issue but as yearly initiative.

Finally, the former Ministry of Agriculture, Fishery and Food, decided to give a major impulse to the event in the context of *Cátedra Pascual Carrión*, an initiative for promoting TICs in Agriculture which would take care of most of mobility and promotion costs.

Therefore it was agreed that BEST Madrid would take care for the call and selection of participants as well as their management all throughout the event, while the Professors would focus on problem statement in conjunction with granted students, as well as taking care for addressing the proper facilities for the event.

4 PROBLEM STATEMENT

Being a call for robotics in agriculture, we wanted to address an issue which would be a true agricultural challenge though affordable within a few days work with untrained participants. Fruit harvesting, a major task in agriculture, was quickly addressed as the topic for the event but to prevent from its seasonal nature we decided to build an artificial dwarf tree forest where the granted students could test the feasibility of selective harvesting.

Several months of partial dedication from granted students, professors and technical staff where needed to adapt students' feed back with professors' idea as well as with regard to practical issues such as fruits definition and way of fruit attachment to the tree and corresponding difficulties for detachment.

At the end it was decided to split the problem into tasks that would be independent at least in two out of the three working sessions scheduled for the event.

Only one week before the event the problem statement got finally ready with the approval of all parties: "Picture your robot, a fully autonomous, sensitive and sensible harvesting machine, working in

a dwarf tree forest on a moon like surface (white). The season for *jujube* fruits (a ping-pong ball shape food) is just about to start, and thus this nice paradise fruit is whitening from orange (immature) to full white (mature). Look at the nice aromatic fruits in the top of the branches that need to be detached from the tree, loaded in a bin and transported along the forest...Would your robot be able to take the challenge?...” (see agrotech09 web for further details [2]).

5 COMPETITION VENUE

The students (a pool of 40 candidates from 16 European countries selected among 120 proposals) were welcomed by BEST on the Saturday 9th of May, and team building took place also leaded by the student organization at the Retiro Park on the 10th. There the students had the opportunity of sharing their own biographies in terms of fields of specialty.

On Monday, 11th the students were welcomed at the School of Agriculture by the Ministry of Agriculture, the Professors involved and the Direction Board of the School. The Philosophy of the contest was described as a learning experience for exploring the power of synergy in the core of multicultural and multidisciplinary teams. The event was defined as a Think Tank that would enhance the achievement of creative solutions for agricultural tasks.

6 WORKING DAYS

On Monday, the teams were asked to develop and program a harvesting tool. Some later comments of the participants may be useful to describe the very preliminary impression: “At the beginning there was a little bit too much information at the same time. The problem was well stated but the way to do it seemed to be complicated. After a moment it was clearer”. By the afternoon a wide variety of mechanical solutions appeared, resembling the so called “cambric explosion”, 7 out of 10 succeeded to detach the fruits from the trees letting them fall to the floor.

On Tuesday, the task was more general having to build a vehicle that would be able to move according a defined path and that would be awake and put to sleep by means of non contact human command: voice, whistle, hand clap. This day the teams finished early according to the schedule with 100% success.

Finally on Wednesday, the teams had to integrate both components (picking tool and vehicle) harvesting as much fruits as possible. Bearing in mind the results of the first day, some teams decided to modify their picking tool and so only 3 main technical solutions remained in the final robots. Since each of the robotic components were managed by dedicated controller, many of the teams had to solve Bluetooth communication while others moved towards a simpler single controller solution to avoid difficulties. At the end of the day, 8 of 10 teams were able to perform with a wide variety of success.

The participants were happy about the help they got from the granted students who were part of the organization: “the assistants were always there and ready to help us”; “the Spanish students were really useful “; “they were helpful in getting started with programming and pointed you in the right direction at the beginning”;” they were giving us examples from the web and they explained very well the subject because they worked on it before”.

According to the student comments, the material which was available from the Spanish course as well as the Wi-Fi internet connection will have to be adapted for upcoming events: “It was difficult to work with the Spanish online material and the internet connection was really slow”.

7 TEAM DEVELOPMENT

Team development showed to be at the core of success: “It was a very interesting competition. It was the first real team cooperation because at school we already know our team. Here it was a real cooperation because we also had to know the mind of our team mates and find how to communicate in the right way. I liked the competition mood, our collaborative feeling. I liked also the serious way to evaluate the robots, the stressing time lack. Good Job!! I will go home with a good impression and more knowledge about work cooperation”.

Whenever enough multidisciplinary knowledge was available, tasks were clearly distributed among participants. In words of the students: “I was glad, I was with them (the team), because we had each

of us kind of a specialty so we were able to share the work and be efficient”; “the best issue in the event was team cooperation and task assignment. I trusted the software engineer and he trusted me”. Moreover, there was clearly a team which was less qualified and though able to succeed due to the very intelligent way to overcome the difficulties by means of decreasing the complexity of the problem and the ability of facing the issue with a positive collaboration: “The task was not so easy at the beginning but we did it at the end, and we felt happy and fulfilled. It was nice to work in team and to cooperate with others”; “It is an unforgettable experience. I met a lot of great people and I had a lot of fun and I gained a wonderful experience of teamwork and building a robot. And I learned that the easiest solution can be the most powerful one”.

8 THE CHALLENGE IN NUMBERS

Fig. 2 will give an overview on the starting point and of the results of the event which was evaluated as clearly successful by both the participants and the organizers.

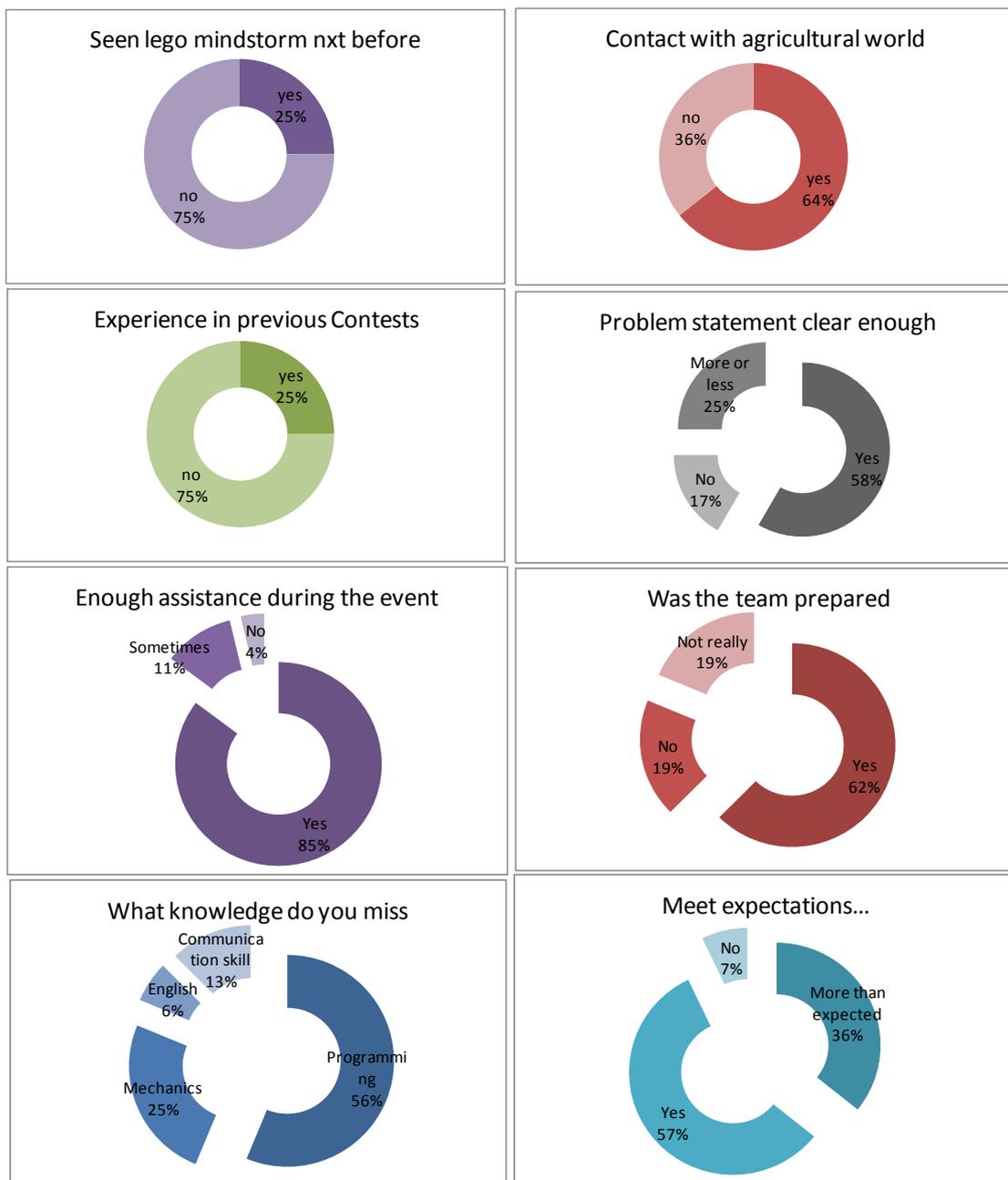


Figure 2. Summary of quantitative features of the event.

When searching for a more qualitative description, let us trust in the words of the students: “I think it is a great opportunity to meet other European students to exchange ideas in matters of current technology and be able to collaborate and co-work for days. It has been an amazing experience and I would like to do it again”; “I think that (Agrotech09) was a good experience, we have put together the 4 words: travel, learn, fun and friends. It was something new for me and for sure I will try again”.

9 JURIES VERSUS STUDENT JUDGMENT

It was interesting to state the level of coincidence among the jury and the popular votes among the student which were done blindly one-another. The first and third prizes corresponded to identical teams, while the second differed (Table 1).

Table 1. Juries and student judgments

The jury									
G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
6 points	9 points	6 points	8 points	5 points	4 points	5 points	2 points	2 points	7 points
	1ST PRIZE		2ND PRIZE						3RD PRIZE
The students									
G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
3 votes	10 votes	2 votes	3 votes	5 votes	1 votes	2 votes	0 votes	1 votes	4 votes
	1ST PRIZE			2ND PRIZE					3RD PRIZE

When asked for difficulties, the teams indicated that they would rather had longer evaluation periods (2 hours instead of 1.5h), also some concerns arose from the lack of clear rating: “We thought we will be having multicolor fruit...Generally we thought at the beginning that task would be more complicated”; “You should have told us your rating system before hand we did not know that collecting a maximum number of fruits in a minimum time is the goal”.

10 FINAL FEATURE

We have already extracted some the impressions/perceptions of the students during the event. Let us only add some global comments on it: “Another experience that widens my horizons”; “Being creative at the university!!”

What about depressions?: “We didn’t have enough time to sleep “; “When the day come to the evening we were tired/stressed and the communication was a big difficulty because of the language(like Babylon tower)”.

But at the end: “I will miss all the wonderful people I’ve met here! I will miss coffee breaks, city walks, and even working sessions (feeling kind of strange without assembling structures today). 50 words? Come on, everything has been already said”.

11 REFERENCES

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