Fitting into their shoes: how robots help multidisciplinary approaches under cooperative learning

Barreiro, P.[1]; Diezma, B[1]; Recio, B.[2]; Fuentes-Mendez, V.[2]; Martínez-Ramirez, E.[3]; Morató, M.C.[2]

[1] Dpto. Ingeniería Rural; [2] Dpto. de matemática aplicada a la ingeniería agronómica ; [3] Dpto. de física y mecánica fundamentales aplicadas a la ingeniería agroforestal. ETSI Agrónomos. Avda. Complutense s/n. 28040 Madrid. Pilar.barreiro@upm.es

Resumen

La enseñanza de ingeniería agronómica está poblada de asignaturas con contenidos altamente específicos pertenecientes a distintas ramas del saber que raramente se integran entre sí de manera profunda. En los últimos años de carrera resulta interesante plantear como reto a los alumnos la posibilidad de poner a prueba los conocimientos adquiridos en agronomía, física, matemáticas e ingeniería en el desarrollo de un robot capaz de realizar una variedad de tareas agrícolas. Este es el marco en el que se ha impartido por primera vez la asignatura Robótica Aplicada a la Agricultura, la adquisición de las competencias necesarias y la discusión de los resultados de aprendizaje son los aspectos que se desarrollan en este trabajo desde la perspectiva de los alumnos que han participado. Metidos en los zapatos de los alumnos.

Abstract

Agricultural engineering is full of subjects with highly specific contents from a wide variety of domains which are barely linked together. In the last years of study, it is interesting to test how deeply the knowledge has been acquired and is required regarding agronomy, math, physics, engineering and computing, by means of trying to build and to program an agricultural robot. Within this framework, Applied Robotics in Agriculture is a course designed to combine the required competences. In this paper, a discussion on the results of learning along this first course implementation is also provided emphasizing highlights and drawbacks.

Purpose and Objectives

The ancient Chinese wisdom from Chuang-Tzu points that all our lectures are like the footprints of our shoes on the sand. Even though being the consequence of our knowledge, these footprints are not really our knowledge. Bearing this idea in mind, we decided to design a learning experience that would allow the students to generate their own footprints by testing what they had learned on agronomy, math, physics, engineering and computing throughout their grade studies in Agricultural and Agro-industrial Engineering at the Universidad Politécnica de Madrid (UPM).

Robotics in Agriculture is a new subject (7.5 ECTS) designed in the framework of what we call an innovative educational path, within the aim of providing a practical scenario for interdisciplinary contents and abilities. Three different Departments are involved: Agricultural engineering, Applied Mathematics, and Applied Physics.

The objective of this paper is to describe the generation of this new subject as an integrated pool of exercises of increasing complexity that ends up with the development of cooperative projects.

Main Features and Personal Resources

The subject uses Lego Mindstorm as a training tool with Lejos (JAVA for lego) as programming language along whole year supervision. Thus, a full set of materials has been bought jointly by the three departments which lead to a new situation with the need for gathering the equipment in a joint laboratory. During the first semester the students face a week program with problem-based education, starting with the design and building of basic mechanisms like gear boxes, manipulators and vehicles, and also learning how to deal with object oriented languages and available Lego libraries.

Since the subject is developed in the framework of an innovation project, it was possible to fund four students in order to facilitate weekly verification of material such as activity sheets before putting it into practice in the classroom. The professors defined the activities two weeks in advance and the collaboration students had to verify that the complexity was adequate for the increasing level of the students. Four main areas were defined: mechanics, programming, engineering and integration, and thus one collaboration student was assigned to each of this topics. The professors referred in this paper held meetings weekly, defining the tasks and matters to be faced. According to the generated guidelines, the collaboration students had interact one another test the feasibility of proposed tasks giving some feed backs to improve the schedule and contents of the course. All information was gathered in a B-learning platform that hold most of the courses at UPM: Politécnica Virtual.

Figure 1 shows an example of activity sheet corresponding to the development of dedicated mechanism, and an example of mechanical tool developed to study 3D path planning.

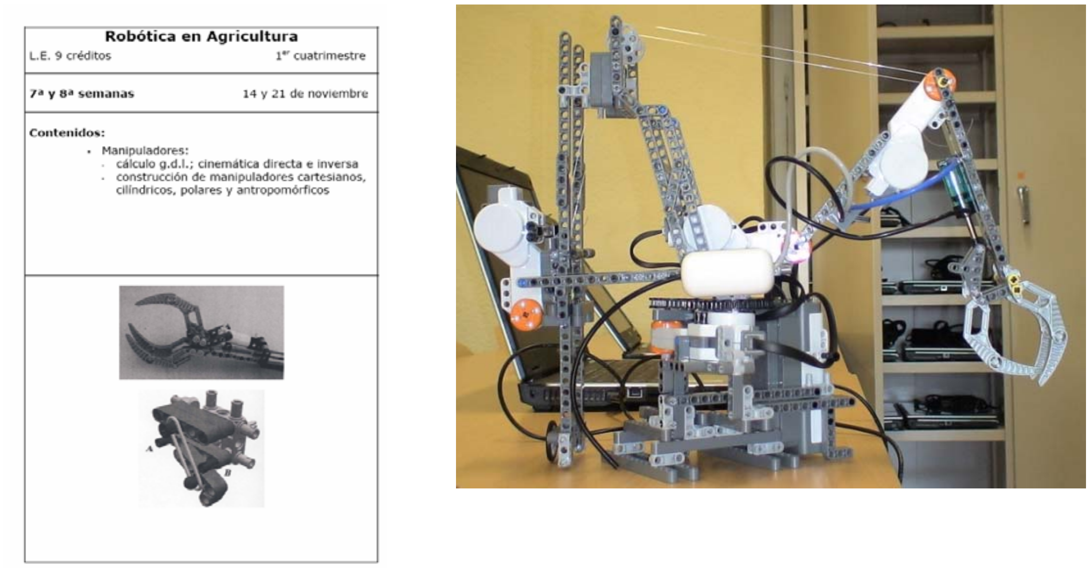

Figure 1. Activity sheet corresponding to the 7th and 8th weeks: kinematics and manipulators (left). Mechanical tool developed to study 3D trajectories.

Another very challenging activity was the development of an adequate procedure for determining the center of gravity (COG) of a vehicle. In this case the collaboration students, following some initial guidelines of the professors, had to develop a supporting platform for the vehicle and at the end optimized a prototype for COG assessment which was very much appreciated by the regular students of the subject (see Figure2).

Figure 2. Supporting platform for the determination of center of gravity of vehicles

All the theory behind the path planning had to be introduced to the students including the definition of homogeneous coordinates and all possible transformations: rotation, translation, scaling and perspective. The collaboration students helped in the development of practices that would allow evaluating the accordance between theory and practice due to the particular mechanical designs of the vehicles. Figure 3 shows the way practice was carried out.

Figure 3. Students testing their vehicles regarding the turning radius.

Up to now, only the details of mechanics, physics and engineering has been provided, however each of the above mentioned activities was companied weekly with the definition of the most suited computing procedures that would allow the robots to perform the tasks that have been indicated. Thus, the basics of object oriented language was given, together with the description of the libraries that allow to program the robot parts such as sensors and motors, as well as the wired and wireless communication tools. The collaboration student that was specialized in programming deeply interacted with those devoted to mechanics and engineering. All programs were uploaded into the b-learning platform so that the regular students could make profit of their work. Figure 4 shows an example of the documentation generated.

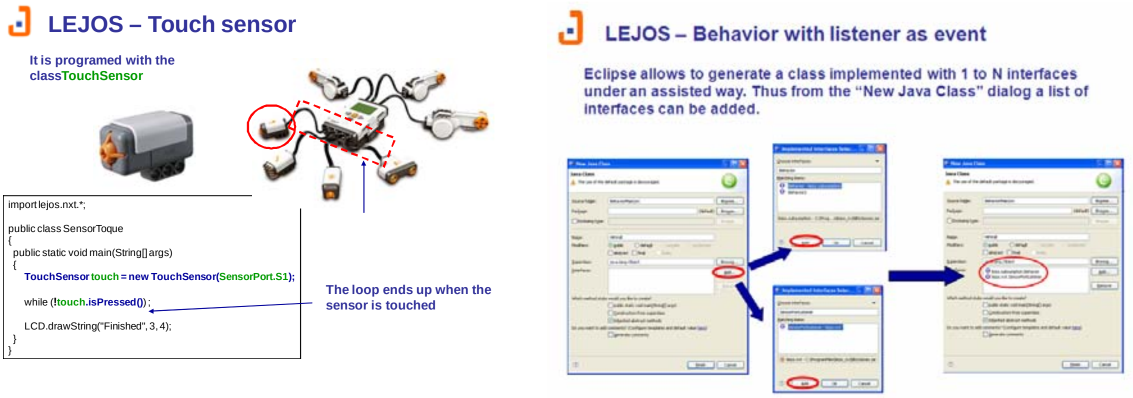

Figure 4. Documentation generated for the training of students in the basics of the object oriented language.

Self development of specific autonomous robots

The second semester the students were requested to develop a complete robot with the ability of performing general as well as agricultural specific tasks, with the restriction of being able to cooperate with another robot developed by a second team. The students work in pairs and have to deal with the need of consensus between the different robots.

The project consisted of: defining a proper title for the robot that included all the specific abilities of the system; the definition of parts and external elements with which the robot would have to interact; the description of the activity by subtask decomposition; building and programming the robot; the description of the evolution of the original idea into the final system within a bitacora notebbok where all restrictions should be clearly stated, as well as the suitability of the platform to face the proposed challenge. A final remark of the success and satisfaction with regard to the results was requested to all participants.

This year, four robots have been developed: exploratory harvester (1) & loading carrier (2), forklift transporter (3) & supplier spider (4). Figure 5 provides sightseeing into the four devices.

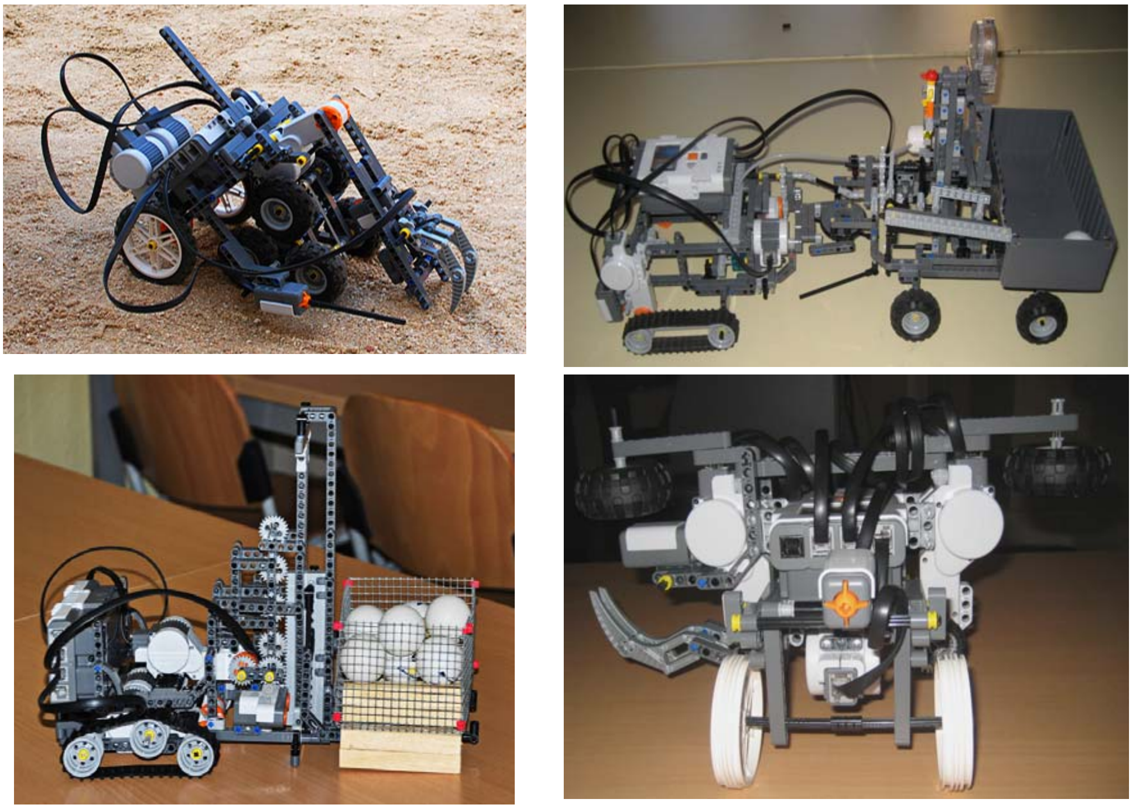

Figure 5. Complete robots developed by the students during the second semester: exploratory harvester (above, left), loading carrier (above, right), forklift transporter (below, left), supplier spider (below, right).

It has been interesting to discover how much the students get involved into their issues. The fact that a worldwide used platform is proposed has allowed the students to find many examples and blogs in the web where they could exchange experiences. The students also found it challenging the need to agree the external conditions that would fulfill the requirements of every pair of robots. It was also interesting to see how the students were able on their own to divide each project into tasks according to each individual skill, so that each of the participants would have their own responsibilities that would have to be integrated afterwards.

Every couple of teams with corresponding projects had to interact due to the existence of a global task, for example exploratory harvester robot should be compatible with the loading carrier one and thus an agreement had to be achieved in terms of the definition of the paths and place for fruit downloading. Another example was the need to achieve a joint definition of the stockholder design for the couple forklift transporter and supplier spider.

In order to provide the teams with all the accessories such as pallets, fruits, paths, aerial structures… the technical staff of the Rural Engineering department had to interact systematically with the students. It was interesting to see how the technicians could transmit the student some very practical ideas and improvement in their designs such as the difficulty of driving the required torque or guarantying the stability of the vehicle.

Drawbacks and Hesitations

The design and construction took two thirds of the time from the second semester, and so we have found that the intelligence that has been programmed is still at a very rudimentary stage. Therefore an interesting conclusion points to the feasibility of using these particular designs for the first semester of the upcoming year, where the problem based learning takes place, in order to start with behavior-programming from the very beginning.

Another important restriction that has popped-up this year, and which will have to be solved for the next edition is the need for providing the students free access to the multi-departmental joint area where the equipment is stored, as to facilitate the time management by the students which is a crucial point.

Major Contributions

The major conclusion is that the students really reinforce previous knowledge, going deeper into the concepts, gaining self-confidence and maturity. Two out of ten students decided to leave due to intense labor and concentration which was required.

A large expectation was generated in the faculty even though the limited number of regular students. It seemed that the mass media had decided to follow the evolution of the subject from outside without taking the risk of following such an intense matter for the first year.

References

- Finkel, D. 2000. Teaching with the mouth shut. Editorial Boynton Cook
- Paz, O.1997. Chuang-Tzu. Editorial Siruela.
- Astolfo, D; Ferrari, M; Ferrari, G. 2007. Building robots with lego mindstorm nxt. Editorial Syngress.