

From Research to Teaching: Integrating Social Robotics in Engineering Degrees

Yolanda Bolea, Antoni Grau, Alberto Sanfeliu

Abstract—When industrial robotics subject is taught in a degree in robotics, social and humanoid robotics concepts are rarely mentioned because this field of robotics is not used in industry. In this paper, an educational project related with industrial robotics is presented which includes social and humanoid robotics. The main motivations to realize this research are: i) humanoid robotics will be appearing soon in industry, the experience, based on research projects, indicates their deployment sooner than expected; ii) its educational interest, technology is shared with industrial robotics; iii) it is very attractive, students are interested in this part of the subject and thus they are interested in the whole subject. As a pedagogical methodology, the use of the problem-based learning is considered. Those concepts are introduced in a seminar during the last part of the subject and developed as a set of practices in the laboratory.

Keywords—Higher education in robotics, humanoid robotics, problem-based learning, social robotics.

I. INTRODUCTION

FOR some years, social robotics has been a subject widely studied. Some European projects about social and human robotics are funded giving an idea that this field of research will be part of the daily life in a next future as well as an important part of the industrial robotics environment [1]. This fact motivated authors to develop the educational project presented in this paper.

Robotics is widely used everyday in industry, and even in other fields not so quotidian such as in space programs or for accessing in dangerous places. But perhaps it could go unnoticed the huge investment in social robotics, with a potential market of 18,000 million dollars for year 2015 [2]. The development fields of those projects are focused on home control and automation, education, health, entertainment and transportation [3].

There exist other universities that impart seminars on social robotics but from a different point of view and different objectives than the seminar that authors propose. In [4], researchers from the University of Freiburg propose a seminar on social robotics where students learn to search for, read, present and summarize a scientific paper, and later on they discuss about each paper. Other universities, [5], present seminars on social robotics as an interaction of human and robots and their social implications but without any

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technological approach. Other research centers devoted to social robotics investigation do not give any lectures on the subject, [6]. Even in [7], one of the pioneering laboratories in robotics states that the bridge from research to teaching is not clear in social robotics. Authors consider that students have to be prepared for this kind of robotics field and for their technological implications.

This paper is divided into different sections. In Section II the context, objectives and methodology of the 'Industrial Robotics' subject in the third academic year in Industrial Engineering degree is introduced. Section III presents the laboratory equipment needed to carry out the proposed project. In Section IV the development of the social robotics laboratory practices with problem-based learning (PBL) methodology is described. Section V concludes the paper.

II. ROBOTICS COURSE

The increasing integration of humanoid robotics in our society gives the chance to incorporate this field in the curricula of the engineering degrees. Therefore, the idea to develop this workshop was born from the desire to introduce to the humanoid robotics in the first courses of engineering degrees. Nevertheless, since the introduction of PBL in engineering courses its positive effects have been widely reported in the literature [8]-[10]. This experimental laboratory is taught in the Industrial Engineering degree at the Industrial Engineering School of Barcelona (ETSEIB-UPC) after an initial part of practices about manipulators and classical mobile robotics. Usually, in this university the only method applied to impart technical education in degree courses for engineering students is the traditional Lecture, Tutorial and Practical (L/T/P) approach. Encouraged by the success of PBL in engineering courses elsewhere in the world, [11]-[13], authors consider the importance of robotics as a basic subject in the curriculum of industrial engineering and a subject very interesting for other engineering degrees due to its multidisciplinary nature. For this reason, authors propose the use of PBL methodology in this specific subject of social robotics.

The laboratory practices consist on three practical sessions of 3 hours each. Therefore, this laboratory accounts for 0.8 ECTS (in the European High Education Space EHEC terms) as a part of the Industrial Robotics subject lasting 3 weeks. In this academic year there are 55 enrolled students distributed into 4 practice groups with a maximum of 15 students each.

Using the PBL teaching methodology the classical concept of L/T/P is removed. The total duration of the seminar was divided into PBL classes of three hours each one every week. Quasi-open-ended practices and project were then framed in

accordance with the topics of the syllabus. The lecturer is a mere instructor and the students acquire knowledge and skills not taught in classroom. PBL encourages students to participate in the whole learning process and stimulates their curiosity. It trains the student to become an independent learner [14].

III. LABORATORY EQUIPMENT

The practices with humanoid robotics are held at the Robotics Laboratory that the Automatic Control Department has available in the Industrial Engineering School. The laboratory has seven Robonova® humanoid robots equipped with ultrasound sensors, infrared sensors, sound sensors and accelerometers. In the laboratory classroom is included a library with books and journals, Internet access and facilities for experimentations (sensors, oscilloscopes, measurement devices, etc.)

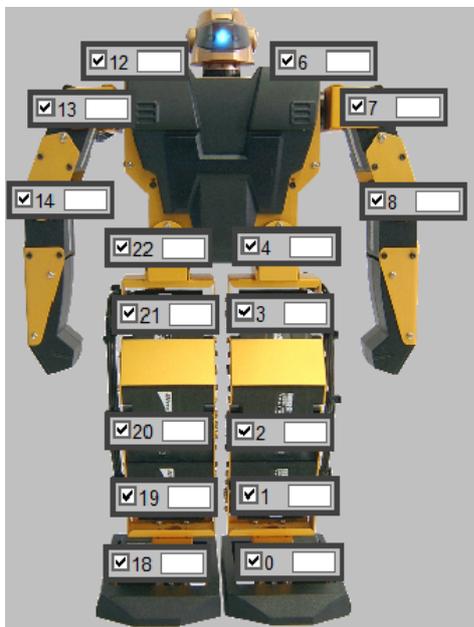


Fig. 1 Servomotors location at Robonova-I HITEC

A. Hardware

Robonova-I from HITEC is a humanoid robot designed specifically to get started in this area of robotics. However, it is also a robot to be used for more experienced people. Its control board permits upgrading both the software and the hardware leading to new possibilities of usage. The robot is 45 cm tall and it weighs 2 kg.

Robonova has 16 operative HSR-8498HB servomotors located as shown in Fig. 1 (6 in the arms and 10 in the legs). Nevertheless, the control board allows up to 24 servomotors. Each servo has a turning range of 180°, but when incorporated into the robot, the rotation range is reduced due to physical constraints. Apart from these servomotors, Robonova uses a MR-C3024 control board. This board contains an Atmel ATmega 128 controller, several I/O ports including 8 A/D converters, a RS232 serial port (ETX/EX) and the possibility

of using an infrared remote control.

Over the basic robot, various sensors have been incorporated. First, an infrared sensor (SHARP GPD12) with distance measurement range from 10 to 80 cm. Second, an ultrasound sensor (Maxsonar EZ1) with distance measurement range from 0 to 6.45 m. Third, a two-axis accelerometer (ADLX322) with g-force measurement range from -2 to +2 g. Lastly, a sound sensor can measure sound up to 80 dB.

B. Software

RoboBasic is the language used for programming Robonova. This language is a variation of the BASIC language designed specifically for humanoid robots. The commands needed to control a robot have been added to the general BASIC programming language, though most of the language still resembles to BASIC. In addition, the default software has some applications in order to create and download programs in the control board to be executed autonomously. The first one is also called RoboBasic. It is the most used programming environment and the application utilized in the script of the experimental sessions. Besides the possibility to create language commands, compile them and download into the robot, it permits to move automatically servomotors in a visual way in order to easily create movements and to capture the value where a servomotor is moved manually by means of the Catch & Play function.

IV. ROBOTICS LABORATORY PRACTICES

Authors are also lecturers in “Industrial Robotics” subject, and they are also instructors in the Social Robotics seminar. After analyzing the available equipment, and further possibilities, as well as the syllabus of the subject and the timeslot in the laboratory, the set of proposed practices are collected in the following subsection.

A. Practice 1: Initial Contact with Robonova Humanoids

Objectives of this practice. The main goals for this practice are:

- Overview and experimentation with the components of the Robonova-I Hitec;
- overview and experimentation with the proposed software;
- To learn how to download programs and commands to the robot and test them through the demonstration program.

After finishing this practice, students will know how the different elements of the robot work and how to use the proposed software (Fig. 2) in order to download their own programs. Therefore, they will be ready to test the robot commands and instructions designed by the students.

Description: In this session, a briefly explanation of all the components of the robot and the software is given. Students learn how to design program codes and commands with the different applications available in the software. They also learn how to download these codes to the robot.

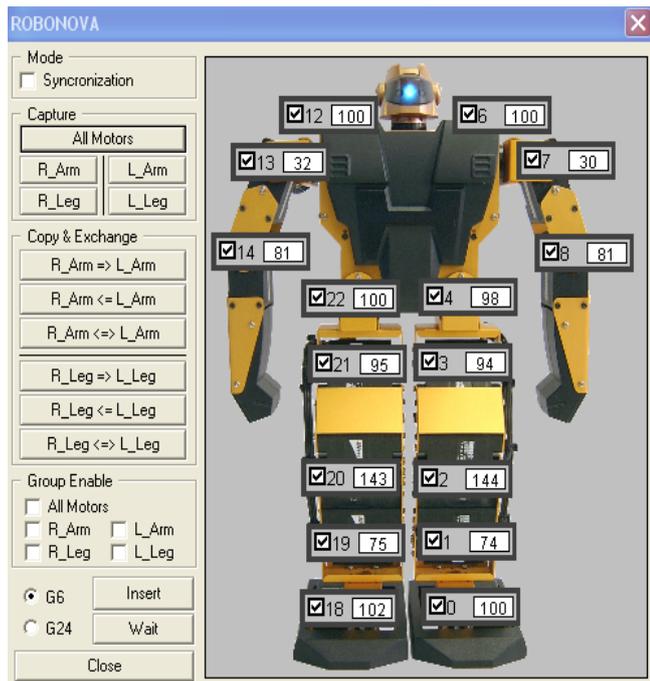


Fig. 2 RoboBasic software applications used to design programs (24 Servo Motors Real-Time Control Window and Robonova Motor Control)

Provided material: A demonstration program included in the manufacturer's software will be given to students in order to be tested on the robot. The demonstration program consists of various movements, each one activated by a button in the remote control. Students must not only test the different movements, but they must also understand the code that executes this motion. This is important because student will have to use some parts of this code and some of the movements in further sessions.

After finishing this practice, students will know how the different elements of the robot work and how to use the provided software (Fig. 2) in order to download their own programs. Therefore, they will be ready to test the designed robot commands and instructions.

B. Practice 2: Open-Loop Control

Objectives of this practice. The main goals of this practice are:

- To understand the hierarchical control structure applied to humanoid robots;
- To understand and analyze the program code used for Robonova;
- To apply the various commands of the demonstration program used in the previous session to create new codes;
- To design and test some simple codes on the robot.

By means of this practice, students will know the concepts and goodness of hierarchical control (Fig. 3) structure and closed loop control and how to apply them in humanoid robotics. They will also have to design and test some easy but useful open loop programs. As a consequence, they will be ready to face the closed loop exercises in which the robot will

interact with the environment.

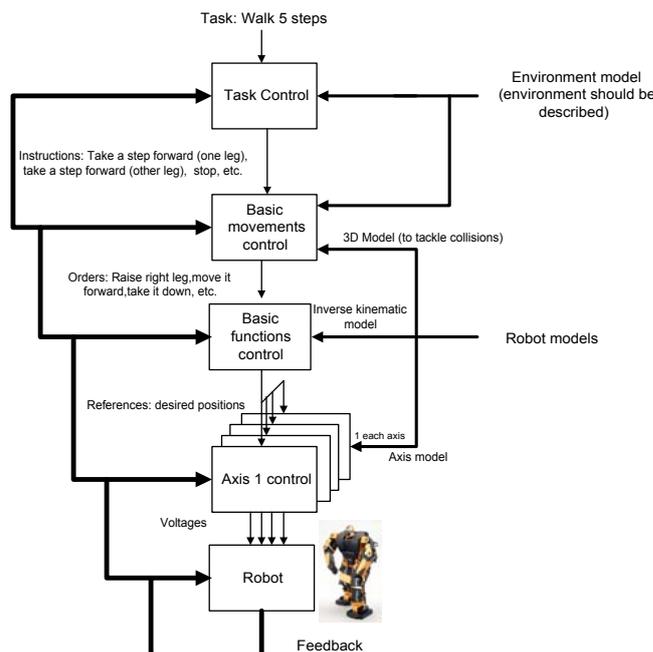


Fig. 3 Hierarchical control structures of a Robonova humanoid robot

Description: In the first part of this practice, some concepts are explained. The first one is the hierarchical control structure applied to humanoid robots. It is shown how this strategy helps to simplify the design criteria in order to make a more consistent control, as well as it makes use of systematic techniques for troubleshooting and optimization. By means of an example, the steps followed through the different control levels during task programming are shown. Next, the concept of open loop control is recalled as well as the advantages and drawbacks when it is applied to humanoid robots.

In the second part, students will have to design some programs to respond to the practice assignment. As it is the first code to be designed integrally by the students, exercises are simple and students can use part of the demonstration program for getting some code lines and use them in their programs. In addition, some help instructions are given to the students to use them in the code. The activities proposed are basic movements that will be used in further sessions such as walking some steps, turning 90° and lateral displacements. Here again, students are also encouraged to make their own creative movements.

C. Practice 3: Closed-Loop Control

Objectives of this practice. The main goals of this practice are:

- To understand the closed loop concept and the need for interaction with the environment,
- To understand the differences between high and low level controls in the hierarchical control structure applied to humanoid robots,
- To apply simple codes designed in the previous sessions

to create more complex codes,

- To design and test on the Robonova robot some codes that incorporate the use of various sensors included in the robot.

Description: Like in the second practice, the advantages and drawbacks of the closed loop control are explained. Among these advantages, it is highlighted how necessary is to use sensors in a closed loop system that controls a robot in order to interact with the surrounding environment. Equally, the differences between low and high control level in a hierarchical control structure are illustrated. After this point, there is a description of the control structure used in the session which consists of a closed loop control at high level (environment interaction) and an open loop control at low level, because this last control is considered as a black box system.

When all the concepts have been pointed out, students will be required to carry out some exercises with the robot to apply these concepts learned in previous sessions. All the different activities proposed use the different sensors mentioned above (infrared, ultrasound, accelerometer and sound) in order to interact with the environment. Students are provided with some commands that are necessary to make use of those sensors.

First, there are some introductory exercises where students will work with each sensor separately. Thus, they will see which values are acquired by the A/D converters coming from the sensor. The ultrasound sensor placed at the front of the robot will be used to measure distances to frontal objects. In a similar way, the infrared sensor located on the right arm will be used to measure distances to lateral objects. The sound sensor will be used to receive orders through loud sounds. And finally, the accelerometer will be used to detect both frontal and lateral falls of the robot.

Subsequently, once students have understood the robot's sensors functionality, they will be required to perform various movements with the robot depending on the combined information provided by the different sensors.

V. CONCLUSIONS

In this article, a Humanoid Robotics laboratory based on PBL is introduced in the Industrial Robotics subject in an Industrial Engineering degree. This practical laboratory has been carried out through experimental sessions based on the constructivist pedagogical methodology of PBL instead of using the classical of L/T/P classes.

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