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# Remote Control of a Robotic Unit: A Case Study for Control Engineering Formation

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**Abstract**— Hands-on experimentation has widely demonstrated its efficacy in engineering training, especially in control formation, since experimentation using Computer-Aided Control System Design (CACSD) tools is essential for future engineers. On this context, this paper describes a case study for Control Engineering formation, based on a new lab practice for the linear and angular velocity control for a commercial P3-DX robot platform, to teach industrial control. This lab proposal includes all the stages involved in the design of a real control system, from plant identification from an open-loop test, to real experimentation of the designed control system. The lab practices proposed has a twofold objective: firstly, it is an interdisciplinary approach that allows students to put into practice the skills from other subjects in the curriculum, facilitating the integration of knowledge. In addition, it allows increasing the motivation of the students by working with a complex and realistic plant. The proposal has been evaluated through the grades of the students, as well as the perception of both students and instructors, and the results obtained allow to confirm the benefits of the proposal.

**Index Terms**— Control engineering, engineering education, remote control, computer-aided instruction.

## I. INTRODUCTION

HANDS-ON experimentation has widely demonstrated its efficacy in general in engineering training [1], [2], [3] and specifically in Electronics Control formation [4]. Because of that, laboratories have become an integral part of engineering curricula.

In recent years, there have been published numerous works that present different proposals for improving engineering education [5], [6], [7]. Some of them focused on Control teaching [4], [8]-[11]. All these works agree on the importance of the experimental component in engineering learning, which can be complemented but not replaced by simulation tools.

Some authors have proposed the use of remote labs [12]-[14], that use real plants that are operated through the Internet, or virtual labs [15], [16], that only provide computer-based simulations. In remote labs, students can send commands and

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received feedback remotely by using a Graphical User Interface (GUI) in a web browser. These remote labs provide a more realistic experience than virtual labs, and they are proposed as a complement, but not a substitute for the face-to-face laboratory work.

Other approaches are based on interactive tools for simulating control systems, using different plant models [17]-[20]. These tools allow having complex plants such as a Quadrotor as described in [20], and they have proved to be a support for teaching and learning control engineering [17], [18] but real hands-on experimentation is still essential for the training of future engineers [19].

An increasing number of works offer different approaches for hands-on experimentation in control engineering training [21]-[26]. Most of these proposals use Matlab/Simulink for controller design, simulation and implementation [21], [22], [23], [25], combined with low cost hardware such as Arduino [21], [22], [25], [26] or Raspberry [22] boards. Regarding the plant to be controlled [21], [22], [24] and [26] chose a Permanent Magnet DC (PMDC) motor, whereas in [23] the authors use a commercial Lego Mindstorms NXT motor system. On the other hand, the authors of [25] describe different plants to be controlled such as: a resistor temperature control or a solar panel tracker.

Concerning the methodology, Project Based Learning (PBL) has proven its effectiveness for engineering education [27], [28], [29]. Moreover, the application of the theory to realistic projects contributes to improving students’ motivation and active learning [30], [31].

In this context, the present work describes a case study for control engineering formation at the University of Alcalá (UAH). The authors present a project-based learning (PBL) proposal that integrates widely used software tools and a complex and realistic plant: a robotic platform P3-DX [32]. The proposal includes all the stages involved in the electronic control systems design process from the plant identification and modelling, to the experimental validation.

The PBL approach has been chosen because it has demonstrated its efficacy in engineering training, and it facilitates the development of the proposal.

The main innovative aspect of this work is the design of the practical activities for a last year Control course with the following contributions:

- The combination of the course contents with previous knowledge giving the student an integrating vision of the different courses in the curriculum.
- The exhaustive preparation of the practical component

using complex and realistic prototypes and with solutions that require both, software and hardware development.

- The proposal of a remote control where plant and controller are nodes of a communication network, introducing concepts close to Industry 4.0.
- The promotion of the student's critical attitude from the design of the solution to the comparison of simulated and experimental results.

Regarding learning outcomes, this case study encourages the acquisition and reinforcement of multiple engineering training skills such as:

- Development of all the stages involved in the design and evaluation of real control systems: identification and modelling, study of system properties, design, evaluation by simulation and implementation for a real prototype. It facilitates the integration of theoretical knowledge of control engineering through its real implementation.
- Combination of theoretical aspects of control systems with the use of widely used Computer Aided Control System Design (CACSD) tools for the control of a realistic and challenging system.
- Study and design of a networked control application, in which the controller (implemented in a PC) and the plant (robot) are linked via a WiFi connection.
- Interdisciplinary approach that allows students to reinforce skills acquired in previous subjects in the curriculum, such as electronics, communications or informatics.

The case study described in this work, not only allows students to address all stages involved in the design of electronic control systems, using CACSD tools applied to a realistic and challenging plant, but also present the following advantages:

1. Plant modelling includes not only the linear model, but also the nonlinear components (dead zone, saturation, etc.) of the real plant, that are obtained by experimental identification, from an open-loop test. In addition, students can study the effects of the remote WiFi connection between the PC (controller) and the robot (plant), such as communication latency or delay.
2. The PBL methodology combined with a realistic and challenging problem to be solved increases student motivation and engaging.
3. The application of an interdisciplinary approach that includes skills from other subjects facilitates the students' knowledge integration.

This rest of the paper is organized as follows: Section II describes the case study. Section III present the main academic results. Finally, Section IV includes the conclusions and future work.

## II. CASE STUDY DESCRIPTION

This section describes the case study, starting with hardware and software tools (in section II.A), the development phases, including some technical results (section II.B), and finally the most outstanding aspects of the new proposal implementation, both from the point of view of teachers and students (section

II.C).

As has been stated in the introduction, the main objective of this work is the development of practical activities that increase the motivation and engaging of students through the use of more realistic and motivating systems. In addition, these activities must combine the use of CACSD tools with the theoretical foundations of both the subject involved, as well as previous subjects, promoting multi-disciplinarity.

With this challenge, it is expected not only to increase the motivation of students with more challenging practical activities, but also to encourage the proposal of original designs based on theoretical foundations, reinforce the competences acquired and promote autonomous and collaborative learning.

In this line, the practical activities have to be face-to-face and project-based, in addition to incorporate all the stages involved in the design of control systems: identification, design, validation and implementation, making use of professional CACSD tools (Matlab/Simulink) and trying to integrate knowledge of other courses in the curriculum.

In order to achieve the objectives, it was proposed to carry out the remote control of a P3-DX commercial robot [32] (Fig. 1(a)), WiFi linked to a computer where the control is implemented. For the design and implementation of the controller, the CACSD tools used are: Matlab/Simulink and the Real-Time-Workshop (RTW, Fig. 1 (b)).

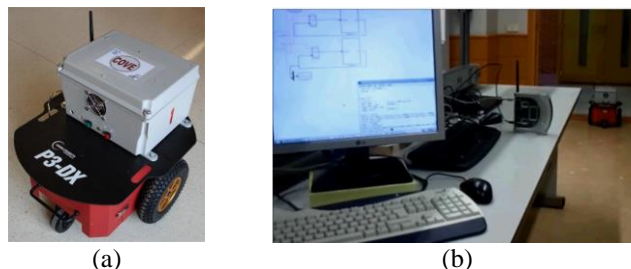


Fig. 1. (a) P3-DX Robot whose control is addressed in control engineering practices. (b) Example of control scheme and connection of the robot via WiFi for remote control.

A general block diagram of the proposed control scheme is shown in Fig. 2.

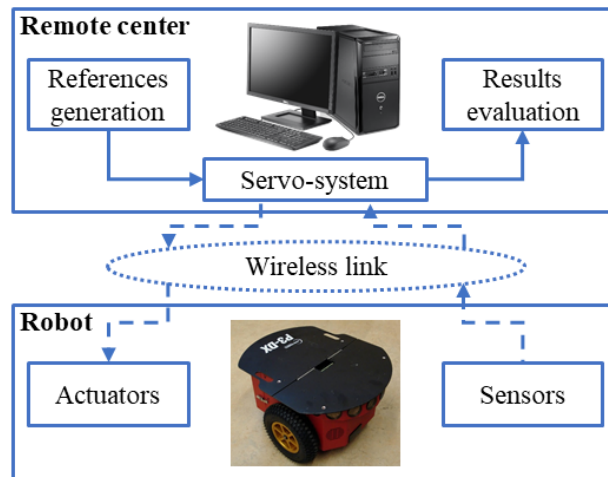


Fig. 2. General block diagram scheme of the remote controller, implemented in a PC, and the plant (P3-DX robot) under study.

As can be seen in Fig. 2, the controller (servo-system) is run in the remote center, where the reference generation and results representation and evaluation are also performed. The control signals ( $V_{cod}$ ,  $W_{cod}$ ) are sent to the robot, and the onboard sensor measurements are returned to the remote center using the available WiFi connection.

The proposal includes all stages involved in the design and implementation of control systems: identification/modelling, design, validation by simulation and implementation for experimental test.

#### A. Plant and software tools

As mentioned in the introduction, it is usual that control engineering labs propose the control of commercial plants, allowing students to focus their efforts on the control solutions. Some examples of widely used plants are the inverted pendulum [34] or the pendubot, or other more complex plants such as the helicopter [36] or the quadrotor [37]. Finally, it is also usual the use of PMDC (Permanent Magnet DC) motors, as shown in [20], [21], [23] and [25].

However, the authors consider that in order to tackle a PBL methodology for engineering undergraduate students training, a more realistic plant could be at the same time more attractive and more challenging. Thus, in the described case study, linear and angular velocities of a Pioneer P3-DX robot [31] are controlled in order to follow a predefined path.

The P3-DX robot platform is a differential drive commercial robot, which maximum speed is 1.2 m/s. The available unit includes a DC-DC converter (Fig. 3(a)), similar to those that students analyze in power electronics courses, a C7 processor at 1.5 GHz, with 1Gb of memory and 80 GB of HDD (Fig. 3(b)) and wireless connection (WiFi).

It also has basic sensors for reactive autonomous navigation, specifically a pair of optical encoders attached to the 500 pulses per revolution (PPR) drive wheels and 8 ultrasonic sensor modules (transmitter-receiver) for obstacle detection and avoidance.

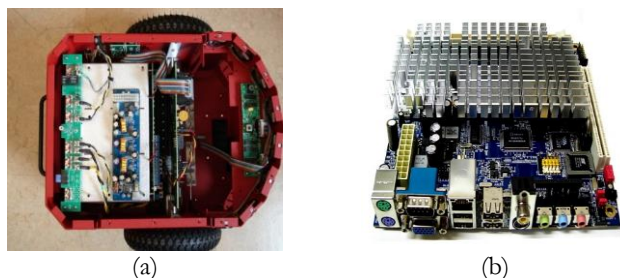


Fig. 3. (a) DC-DC converter (b) Board that includes a C7 processor.

It is in this platform where the students design and first test the control algorithms they propose (using CACSD tools) and then they validate, using the WiFi communication driver, on the real P3-DX robotic platform.

Thus, the CACSD computer tools used to control the robotic platform include:

- The operating system Linux CNC 0, that is an operative system specific for PCs running real-time applications.
- Matlab/Simulink including control related toolboxes and blocksets, as well as RTW for automatic code generation.

It is worth to highlight that the used tools allow to automatically create real-time applications from the control libraries and run them on dedicated target hardware. In order to have a communication between the controller in the PC and the P3-DX robot, it is required to have a driver block, that is implemented using an S-function block in Matlab/Simulink. Fig. 4 shows the Matlab/Simulink software driver designed to access the P3-DX robot in real time, through its: linear speed (" $V_i$ " and " $V_o$ ", plant input and output respectively) and angular speed (" $W_i$ " and " $W_o$ ", plant input and output respectively).

Regarding the code generation, RTW tool allows generating source code that can be compiled under a Linux CNC 0 system, and then run as a real-time application.

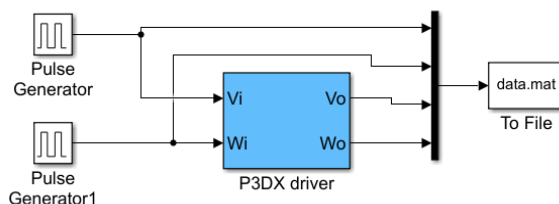


Fig. 4. Software driver for Matlab/Simulink for real-time access to the P3-DX robot.

#### B. Development stages and experimental results

The methodology followed in the learning process is summarized in Fig. 5. The starting point is to design the application to be implemented in the remote center and robot that allows them to be communicated bidirectionally (wireless connection by means of sockets).

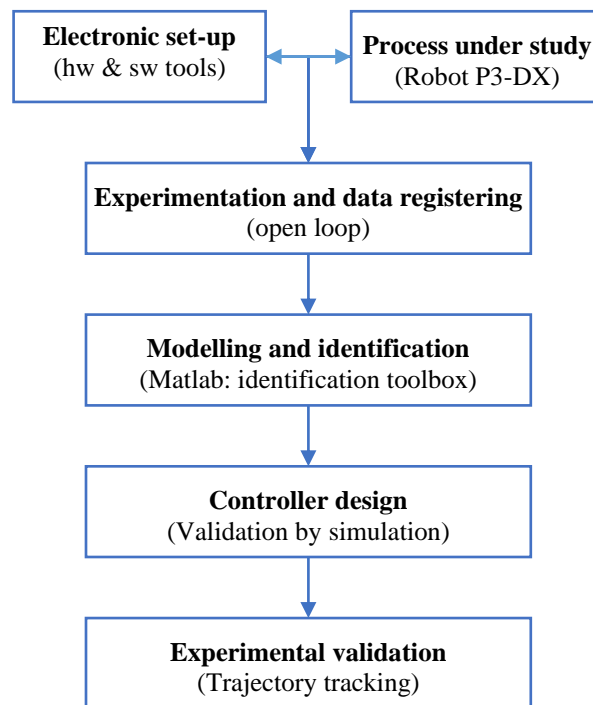


Fig. 5. Proposed methodology: from data registration to control experimentation.

The open-loop test is then designed to detect dead-zone and saturation as well as the linear component of the state-space

model, including the corresponding delays.

Fig. 6 shows the robot's response to ramp type inputs for detection of dead zones ( $V_{\text{dead}}=0.020\text{m/s}$ ,  $W_{\text{dead}}=0.075\text{rad/s}$ ) and saturation ( $V_{\text{sat}}=0.749\text{m/s}$ ,  $W_{\text{sat}}=1.740\text{rad/s}$ ), also a step input allows detecting the delay including the communication channel. On the other hand, Fig. 7 shows the open-loop response of the robot, linear and angular velocities, to step inputs in the linear range.

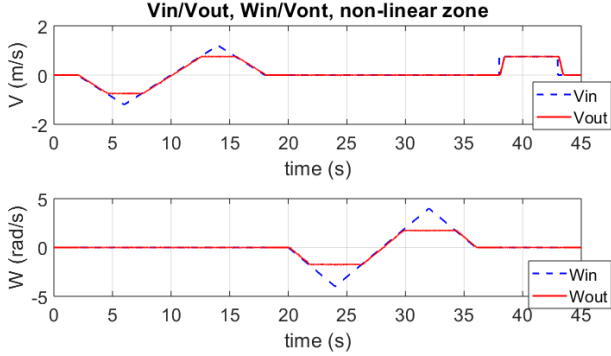


Fig. 6. Signal sources and robot response to detect non-linearities: dead zone, saturation and delays.

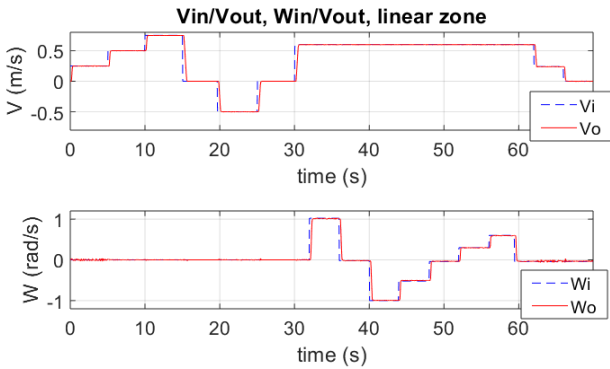


Fig. 7. References and registered outputs of linear and angular velocities with robot working in linear zone.

Given the robot's response to step type inputs, and having evaluated the delays ( $d=3$ ) experienced by each speed for a period of  $T=50\text{ms}$ , the model structure with  $n=6$  states is shown in Fig. 8. The robot dynamic is characterized by  $\beta_v$  and  $\beta_w$ , while the static gain of the model is also affected by the parameters  $\alpha_v$ ,  $\alpha_w$ ,  $K_v$  and  $K_w$ .

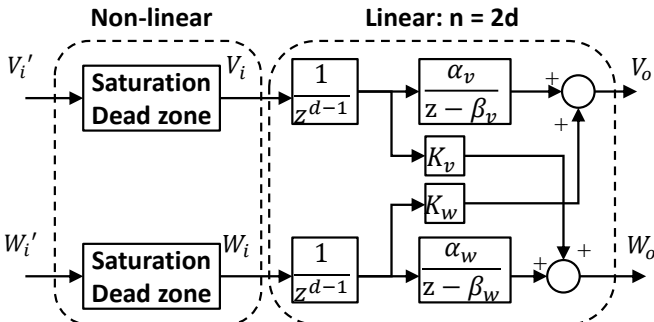


Fig. 8. Model approach considering linear and non-linear components, being  $d$  the number of delays for V and W, and  $n$  number of states of the state space model.

Focusing the study on the linear model and with the distribution of states shown in Fig. 9, the state (eq. (1)) and output (eq. (2)) equations of the robot model are obtained in discrete time, being  $u = [V_i \ W_i]^T$  the input vector,  $y = [V_o \ W_o]^T$  the output vector and  $x \in \mathfrak{R}^6$  the state vector.

$$x_{k+1} = \begin{bmatrix} \beta_v & \alpha_v & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \beta_w & \alpha_w & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} x_k + \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix} u_k \quad (1)$$

$$y_k = \begin{bmatrix} 1 & 0 & 0 & 0 & K_w & 0 \\ 0 & K_v & 0 & 1 & 0 & 0 \end{bmatrix} x_k + \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} u_k \quad (2)$$

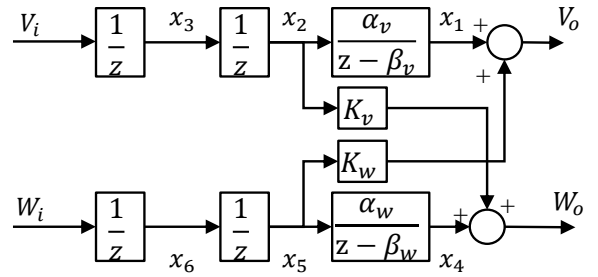


Fig. 9. Linear components of the robot model, where inputs, states and outputs are located.

Using the Matlab Identification Toolbox for a parametric identification (Grey Box) the following parameters are obtained:

$$\alpha_v = 0.194, \quad \beta_v = 0.808, \quad K_v = 1.2 \cdot 10^{-4}$$

$$\alpha_w = 0.143, \quad \beta_w = 0.795, \quad K_w = 1.0 \cdot 10^{-4}$$

The application example consists of the student designing the appropriate linear and angular velocity profiles for the robot to follow the path leaving Lab L03 (origin point O in Fig. 10) and entering Lab L02 (destination point D in Fig. 10). The only restriction is the dimensional limits of the labs' area shown in Fig. 10.

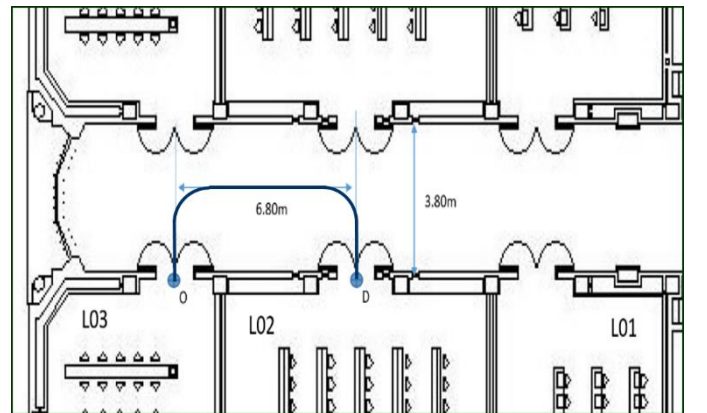


Fig. 10. Map of the working area. EPS-UAH laboratory corridor L01-L06 and reference path to be followed by the P3-DX robot from origin point O to destination point D.

An example of linear and angular velocity references, taking into account the robot's saturation limits, are those shown in Fig. 11.

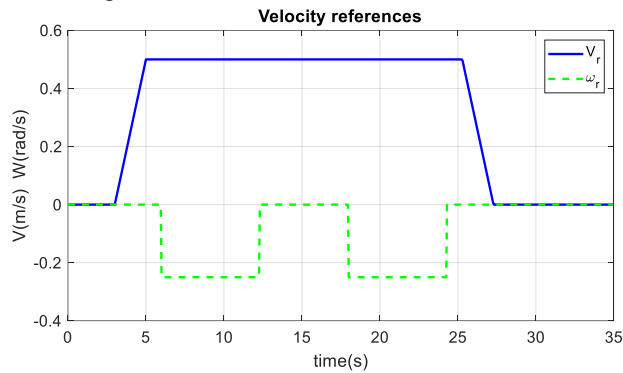


Fig. 11. Example of linear and angular velocity references to trace the path shown in Fig. 10.

The next step is the design of a linear and angular velocity servo system with state observer for the model obtained in the identification process. The procedure is similar to the one described in [26].

The results obtained from the execution of the remote-control system of the P3-DX robot are shown below. The velocity registers  $V$  and  $W$  obtained from the encoders of the robot itself are shown in Fig. 12, the velocity following errors in Fig. 13. The temporal evolution of the pose (displacement  $x$ , displacement  $y$ , orientation  $\theta$ ) obtained from the kinematic model of the robot is shown in Fig. 14.

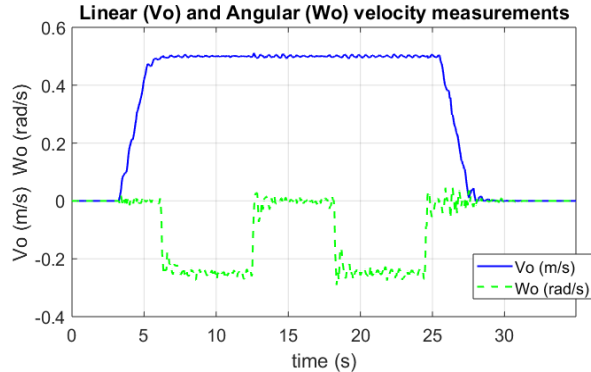


Fig. 12. Recording of linear  $V$  and angular  $W$  velocities obtained from the encoders associated with the robot's active wheels.

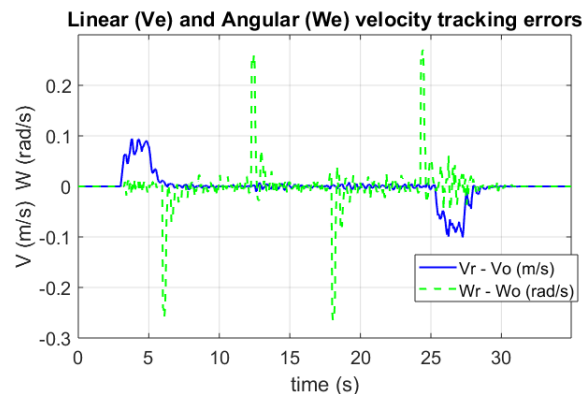


Fig. 13. Linear and angular velocity tracking error when executing the control algorithm at the remote center.

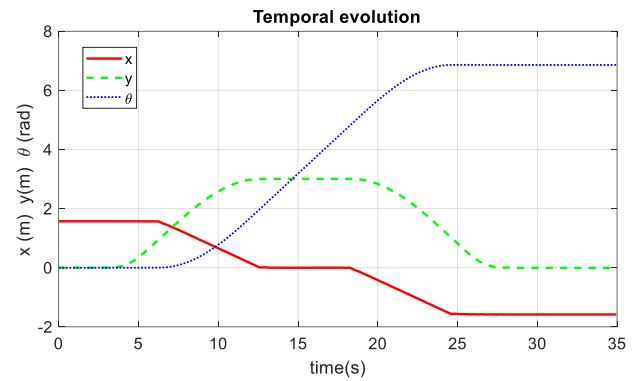


Fig. 14. Time evolution of the position ( $x$ - $y$ ) and orientation  $\theta$  of the robot when executing the path in Fig. 10.

### C. Teaching and learning key aspects

The proposal described in this work has been implemented and evaluated during two academic years (2017-2018 and 2018-2019). Since Industrial Control is an optional course, the number of students varies significantly from one year to another, being the average number of students 25. More specifically, 29 students took part in the 2017-2018 academic year, while in the 2018-2019 academic year the number of students was 23. Besides, 3 instructors were involved in the course during both years.

A half of the course face-to-face hours (30 hours) are dedicate to practical sessions in the laboratory. Throughout all these sessions, students face the task of designing, simulating, implementing and evaluating a speed control for a P3-DX robot. To address it, they must put into practice multi-disciplinary knowledge, some related to other subjects in their curriculum. This multi-disciplinarity allows students to integrate knowledge and make connections across different subjects in the curriculum. In addition, they must develop and justify original proposals for the problem resolution. During each of these practical sessions, 3 instructors provide support to students in case they need it.

In order to determine the pursuit learning outcomes acquisition degree, the following aspects are evaluated:

- ability and initiative to identify and model real systems,
- ability to design a tracking system for a multivariable plant,
- ability to integrate knowledge of electronics, communications and control theory, and to apply it to the controllers' implementation for real systems.
- ability to critically analyze simulated and experimental results of a multivariable control system.

The assessment of these learning outcomes acquisition is carried out using different tools. Throughout the term, the instructors monitor the students' daily work in the laboratory, observing the work done and asking questions about it. During these sessions students must show and justify all their design decisions as well as intermediate results.

In addition, students must present two written reports (one at the middle of the term and the other at its end) in which they describe and justify all the decisions made throughout the process of design, simulation and implementation of the

control system, and carry out a critical analysis of the results. It is important to highlight that, both during the daily work evaluation and in the reports correction, instructors provide feedback to students about their performance.

The implementation of this type of initiatives represents an important challenge not only for teachers, but also for students.

In the proposal described above, the speed control of a complex and realistic plant (Pioneer 3-DX commercial robot) is addressed. This initiative requires teachers to make an extra effort to tune it at the hardware level, as well as to develop the necessary software (WiFi communication driver) for control from Matlab/Simulink. Likewise, teachers have required a training process to know the main characteristics of set-up. It should also be noted that they must be able to solve possible hardware and software problems that may arise during practical classes. In case of problems with the hardware or software used, teachers should be able to help students to solve them in a way with the least possible impact. In addition, for situations where failures cannot be resolved at the time, back-up robots and PCs are necessary. As it has been explained before, in order to successfully solve potential problems and monitor the daily work of the students, three instructors are present in the practical sessions.

With respect to the students, the chosen plant allows them to put into practice the knowledge acquired in the subject with a realistic MIMO (Multiple Inputs, Multiple Outputs) system. The use of this realistic control prototype increases their motivation, however, the number of inputs and states makes the controller design complex, so they must devote a significant effort in carrying out the practices. In addition, the lab works integrates competencies from previous subjects in their curriculum, which students must review to address the proposed work. Although the integration of multi-disciplinary knowledge improves their training as engineers, the additional effort required to take an active role in their learning process causes some students to leave the course, especially those who are used to teacher-centered rather than learner-centered methodologies. It should be noticed that despite this slight increase in the number of dropouts, there has been a significant increase in the number of students who successfully pass the course, among those who study it until the end.

Finally, teachers must consider that there may be students who take the laboratory without having taken any of the previous related subjects, so they must propose alternatives (such as optional seminars, one-to-one tutorials, etc.), so that these students can also achieve the objectives.

### III. RESULTS

This lab proposal has been implemented during the last two academic years in the Industrial Control course, an optative subject in the 4<sup>th</sup> year of the Degree in Electronic Engineering of Communications at the University of Alcalá. There has been analyzed both, the students' grades, and their perception about the course.

The students who pass this Industrial Control course, must demonstrate its knowledge about control theory in the state-space as well as their ability to transfer theoretical knowledge (from this and other curriculum subjects) to the implementation of robotic controllers. So, they must be able to:

- Identify the linear and non-linear components of the dynamic response of a real multivariable system. Obtain a mathematical model from experimental data of the real plant and express the linear components of the model in the state space.
- Design a state-space tracking system with state observer for a real plant. To do that, students must put in practice its knowledge about control fundamentals in the state space.
- Evaluate the designed control system through simulation, using CACSD tools, analyzing all the variables of interest in the control scheme (error, plant input, estimated states and output), and understanding the effects of non-linearities and disturbances.
- Implement the controller (from a Simulink diagram) using RTW, and real-time running, obtaining results from the robot.
- Evaluation and critical analysis of the obtained results, from both, simulations and real implementation, and comparison between them.

The assessment of the acquisition of the previously described competences in the lab, has been carried out using different instruments: daily work supervision, personal questions and written projects. The results for the ordinary call, using the previous methodology and the proposed one are shown in Table I. The results for the previous methodology correspond to the three academic years in which it was applied (2014-2017), while those of the proposal are for the two last years (2017-2019).

TABLE I  
AVERAGE RATES OF THE STUDENTS GRADES FOR THE PREVIOUS AND THE PROPOSED METHODOLOGIES FOR TWO ACADEMIC YEARS.

	Previous Methodology	Proposed Methodology
Outstanding (9 -10)	4 %	6 %
Good (7 – 8.99)	47 %	38 %
Pass (5-6.99)	30 %	39 %
Fail (0-4.99)	14%	6 %
Did not take the exam	5 %	11 %

As can be seen in Table I, the introduction of the new methodology has led to a small increase in the number of students that do not take the exam in the ordinary call. This can be due to the increased effort needed on the part of the students to address the new challenging practical activities. However, there has also been an increase in the percentage of students passing the subject and with the highest rate, due to the extra motivation related to the new methodology. It can be

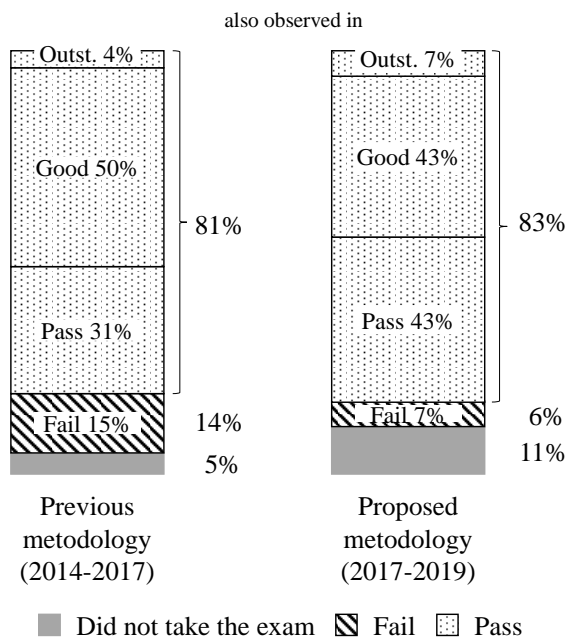


Fig. 15, which shows the percentage of students who passed, failed or did not take the exam for each of the methodologies, with respect to the total number of students. Furthermore, on each column there are shown the percentages of students who fail, as well as those who obtain passing, good, and outstanding marks with respect to the total number of students who take all the assessment tests. By analyzing the learning outcomes of those students who follow continuous assessment, there can be observed an improvement in their performance in the different assessment tools. Thus, the percentage of students who do not pass the subject has been reduced by half (from 15 to 7%) with the new methodology. Likewise, the percentage of students who obtain an outstanding grade has increased from 4 to 7%.

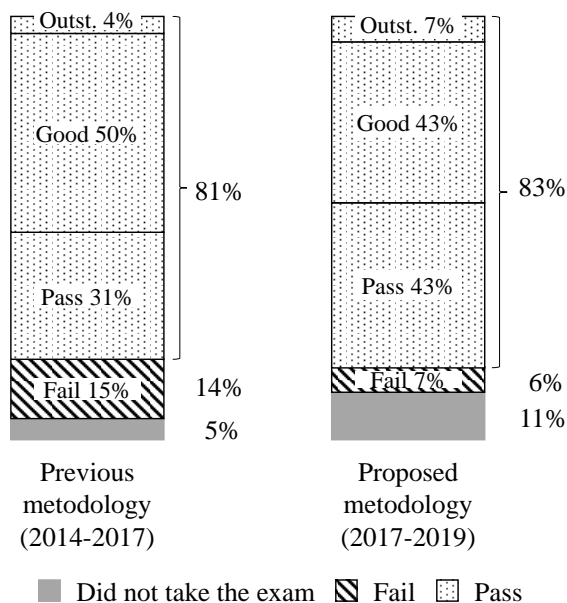


Fig. 15. Percentages of students who pass, failed and did not take the final exam for two academic years with respect to the total number of students, and percentages of students who obtain a mark of fail, pass, good and outstanding with respect to the number of students who take all the assessment test.

For the qualitative assessment of the proposal, students were asked to fill out an optional and anonymous survey in which they were to assess different aspects related to laboratory practices (between 0 and 10), as well as indicate which were the most positive aspects and which ones should be improved. Table II shows the aspects to be assessed, as well as the average value and standard deviation of the answers given by the students.

In Table II, it is worth noting the scores in questions 2, 5, 6 and 9 (highlighted in gray in the table), related to the coordination between theoretical and practical classes, the improvement of the learning process by applying the theoretical foundations to real systems and the integration with other subjects. In addition, students consider that the practical training acquired in the subject is important for their graduate training.

In relation to the aspects that the students consider most positive, the possibility of putting into practice the studied control fundamentals, as well as the freedom when designing the control system, stands out. Regarding the proposals for improvement, although some students demand more guided practices and less workload, others plan to increase the number of laboratory sessions, and even deal with more complex and open tasks.

TABLE II. Average (mean) and Standard deviation ( $\sigma$ ) values of the results of the assessment survey of Industrial Control laboratory experiments answered by the students.

Aspects assessed	Mean	$\sigma$
The contents and planning of the laboratory experiments facilitate learning.	7.75	1.48
There is coordination between the theoretical and practical classes of the course.	8.67	1.50
The resources available in the laboratory are appropriate.	8.25	1.76
The level of the experiments and the workload are appropriate.	7.33	1.56
The experiments proposed facilitate the learning of the course by allowing the concepts studied to be applied to real systems.	8.42	1.31
The integration of knowledge of this course with previous courses (Electronics and Control) contributes to the complete formation of the student.	8.08	1.44
The approach of the classes facilitates the accomplishment of the laboratory experiments and the formation of the student.	8.00	1.76
The supervision of the professors contributes to detect deficiencies of training and improve the use of the laboratory experiments.	7.50	2.15
Do you consider that the practical training acquired in this course is important for your graduate training?	8.08	1.56
What is your overall opinion of Industrial Control laboratory experiments?	7.83	1.47

#### IV. CONCLUSIONS AND FUTURE WORK

This paper presents the proposal implemented for improving electronic control learning process in electronics and industrial engineering degrees. This is an innovative challenge that contributes to increase student motivation by including experimentation with a real robot remotely



controlled, approach close to the industrial environment. In addition, the developed work allows to foment the active learning and to improve the formation of the students in aspects related to industrial control, encouraging originality in the search for practical solutions based on theoretical foundations. Simultaneously, it facilitates the integration of multi-disciplinary knowledge of previous subjects related to control, wireless communication, embedded systems or power electronics. The described proposal also increases the student's motivation when faced with real engineering problems. In this particular case, remote control of processes, incorporating typical concepts of Industry 4.0. Likewise, the acquisition of habits of critical analysis and comparison between simulated and experimental results is promoted.

The implementation of this type of initiatives also requires an extra motivation not only for teachers who must make an extra effort in planning and preparing both the software tools and the hardware platform, as well as the new material for the practices, but also for students whose effort and dedication are required to carry out the planned activities. Furthermore, students must take an active role in their learning process. The authors consider that this proposal allows students to acquire a deep, long-term and multi-disciplinary knowledge, while improving transversal skills such as teamwork. This is reflected in an increasing percentage of students who successfully pass the course. However, there have also been students who drop out of the course, especially those who are unable to attend to practical classes regularly. In this regard, additional effort is also required on the part of instructors to supervise and motivate students.

In addition, both the teachers and the students involved give a positive assessment of the new activities, which allows us to continue supporting this type of initiatives in the training of subjects related to electronic control in different engineering degrees.

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