

Title: Multivariable Control within the scope of the course unit Industrial Robotics

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Activity: Teaching Assistance (TA) – Industrial Robotics ([EEC0093](#))

Motivation:

I always wanted to teach high education alongside with researching. Currently, I teach clarinet at a local music school. In the past, I was a monitor on the course unit Project FEUP of the ECE master's program at FEUP. So, I see the opportunity of being a teaching assistant given on the curricular plan of Special Topics as a unique one to have the experience of teaching high education.

Abstract:

The current curricular plan of Industrial Robotics formulates the robotic manipulators control with control laws for each joint of a manipulator based on a single-input-single-output model. This approach usually implements proportional-derivatives controllers for positioning control of each joint and inverse dynamics control for eliminating the offset in steady-state. However, coupled effects are regarded as disturbances to the individual systems. Also, if the parameters of the system are not known exactly or unmodelled dynamics are not considered such as joint flexibility, the ideal performance of the single-input-single-output models cannot longer be guaranteed [1].

Multivariable control focus on implementing robust and adaptive control to maintain performance in terms of stability, tracking error despite nonlinearity, dynamic model changes and external disturbances, among others. Indeed, multivariable control provide more rigorous analysis of the performance of control systems, while designing robust and adaptive nonlinear control laws that guarantee stability and tracking of arbitrary trajectories [1]. In the literature, multivariable control is implemented with, for example, fuzzy logic controllers [2], predictive control [3], adaptive control [4], [5] or adaptive neural networks [6].

Therefore, the goal is to introduce a module on multivariable control into the curricular plan of the Industrial Robotics course unit. The module will be introduced in a theoretical class followed by a laboratorial work to implement multivariable control in a SimTwo-based simulation environment [7].

Work Plan:

The work plan is divided into XYZ tasks described in Table 1. The estimated total workload of the teaching assistance activity is 328 hours (~324 hours = 12 ECTS). The work will be supervised by Professor António Paulo Moreira, responsible for the course unit Industrial Robotics.

Table 1: Work Plan

#	Description	Hours
1	Study the theory of multivariable control formulated in the book <i>Robot Modeling and Control</i> [1]	40
2	Study of the existent literature about multivariable control	55
3	Familiarization with the SimTwo [7] simulation environment when considered elastic joints	25
4	Develop a SimTwo-based simulation environment with the implementation of multivariable control on a robotic manipulator	55
5	Prepare a presentation with the theoretical background on multivariable control	30
6	Elaborate a laboratorial work for the course unit Industrial Robotics	45
7	Lecture a theoretical class about multivariable control	2
8	Teach in laboratory/practical classes (2 lessons per class, with a total of 4 classes)	16
9	Evaluation activities	20
10	Elaborate the final report for the course Special Topics	40

Deliverables:

- Presentation on multivariable control for robotic manipulators (max. May 9th)
- Laboratory work on multivariable control (max. May 9th)
- Final report (max. June 21st)

References:

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- [2] S.-J. Huang and R.-J. Lian, "A hybrid fuzzy logic and neural network algorithm for robot motion control," *IEEE Trans. Ind. Electron.*, vol. 44, no. 3, pp. 408–417, 1997, doi: 10.1109/41.585840.
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- [6] L. Yu, S. Fei, L. Sun, and J. Huang, "An adaptive neural network switching control approach of robotic manipulators for trajectory tracking," *Int. J. Comput. Math.*, vol. 91, no. 5, pp. 983–995, 2014, doi: 10.1080/00207160.2013.813021.
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