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IFAC-PapersOnLine 49-6 (2016) 291–296

Proactive Teaching of Mechatronics in Master Courses – Project Case Study

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Abstract: University education of young people in very complex branches like robotics is nowadays an issue. Methods like e-learning, distance education etc. are implemented. The authors of the article consider that practice courses play an irreplaceable role in mechatronics education. The paper deals with description of internship concept of French Military Academy of Saint–Cyr for master degree students. A real system of robot arm manipulator playing a Tic Tac Toe game with a human is presented as a case study of a typical issue solved by the students.

Keywords: Arm movements, cameras, computer vision, control education, image matching, inverse kinematic problem, robot arms, artificial intelligence, minimax techniques.

1. INTRODUCTION

This paper deals with the problem of mechatronics teaching for master degree and describe some experiences from teaching at an academic level to the project work made by students during an internship. It is divided into four sections and organized as follows. The first section describes the educational background at French Military Academy of Saint–Cyr. A second section introduces a typical problem solved by master degree students, the Tic Tac Toe game, and presents solutions for the most significant parts. While the third section shows one complete system built on top of some available solutions, the final section sums up the conclusion of the paper and packs some guidelines for future interships.

1.1 Science curriculum at French Military Academy of Saint–Cyr

The students trained at Saint–Cyr have background either in science or humanities. This article focuses on the students who pursue science at the academy. Those students are enrolled in a master's degree (*engineer* degree).

After one term of common framework studies, they choose to major in one of three specializations: mechanical engineering, computer sciences or battlefield electronics. The lastly mentioned major deals mostly with signal processing, communication, radar, electromagnetic propagation, image processing, robotics, analog and digital electronics, simulation tools, etc.

The students also have to attend a three months long internship abroad at the end of their curriculum in order to fulfill the programme requirements.

1.2 About the Students Majoring in Science

The students majoring in science are recruited after a nationwide examination. Before enrolling, they also finish another higher education curriculum, mainly in the two years of preparation for the national examination. Therefore they are usually around 20 years old when they first arrive at the school. They already are familiar with the use of a computer, mobile and other digital technology because they use them since their early age. They are also used to a fast changing world and enjoy a frequent switching in-between their activities. The students, same as the Y generation they belong to, can be primarily seen as technology users. Although their understanding of the technology that they use on a daily basis might be quite limited.

1.3 Saint–Cyr Pedagogics

The higher education provided at Saint–Cyr is a balance between lectures, exercises and practical work. Several projects of different sizes allow the students to deal with design phases which every engineer has to manage. As these projects become more and more complex, the students get used to problems that are more and more difficult to solve. In order to solve those problems, the students need to use the knowledge they acquired during their lectures and exercises. They also need to analyze the problem in details and look for different types of solutions available in the literature.

The requirements to solve these kinds of problems are: continuous work on the project on a mid to long term basis, rigorous methodology and ability to make decision without perfect knowledge. For example, when different groups are working on different subsystems of the whole system, the students don't have perfect knowledge of the implementations or solutions found by other groups.

Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2016.07.192

The abilities and competences of the students which we seek to develop through their curriculum are not usually acquired at the time when the students arrive at Saint–Cyr. So we develop their self-discipline, rigorous methodology to analyse complex problems and their faculty to make decision under uncertainty.

1.4 Internship Expectancies

As previously mentioned, the students end their curriculum with a three months long internship abroad. It allows them to complete their engineer degree, while at the same time, they can get used to other cultures and ways of life and learn different ways of thinking by using different viewpoints.

In the scientific field, internship opportunity is provided mostly by industrial production companies or university laboratories. The aim of the internship is usually to solve a complex problem and it should be carried out in field that corresponds to the student's curriculum. During their curriculum at Saint–Cyr, the students learn how to analyze and decompose a problem into simpler sub-problems to solve.

This decomposition step is necessary to grasp the complexity of the problem. The sub-problems, the structure of the overall system and some way to accomplish functionality can then be defined, simple procedures for complete testing can be designed and limitations can be assessed. Once several subsystems are built, integration test is mandatory to check compatibility issues and to evaluate possible further limitations. If these limitations are too big, it might be necessary to redefine the subsystem design. In case of flawless integration, the whole system is built and a full system analysis of limitations is performed. A careful study of these limitations allows future evolution of the project in order to achieve better performance, to reduce cost or to introduce new functionality.

1.5 Robotics at Saint–Cyr

Robotics is taught to students majoring in Battlefield Electronics (see Danet et al. (2014)). As robots are usually complex systems, the students need competences originating in several domains. Therefore, the students are trained in the following aspects of robotics: control, sensors and actuators, image analysis, direct and inverse kinematics, motion generation, obstacle avoidance. Those topics are explained by researchers and/or lecturers specialized in electronics, image processing and mechanical engineering.

The aim of the topics covered by robotics is to give the students the tools required to solve problems related to robots: localization, motion planning, motion analysis, image analysis, implementation of electronic devices to interface sensors and actuators (see Grepl (2011)). There are also some topics that are not covered by our courses. Power electronics and artificial intelligence are among them. So the students use either integrated circuits or integrated solutions to solve the problems at hand.

1.6 Saint–Cyr Internship at UoD in Brno

For more than 10 years, Saint–Cyr sends every year one or two students for an internship at University of Defence of the Czech Republic in Brno. The topic of the internship deals mostly with robotics. It's a perfect way for our students to use their skills to find solutions for problems of real robots.

2. PROJECT DESCRIPTION

The department of Air Defence of University of Defence possesses a very commonly used robotic arm, as depicted on Fig. 1. The idea is to use this robotic arm to allow interaction between our system and a human while using several pre-defined types of tasks. The choice we made was to choose a game, which gives more motivation for students. Moreover, the rules of the game should be kept simple to allow students to analyze it and find good solutions using a quite simple system. The game chosen was the famous Tic Tac Toe.

In practice, the game is made up of a board on which a user and a robotic arm will put stones to define lines of three elements (vertical, horizontal or diagonal).

There should be four following identified subtasks as:

(1) robot arm control,
(2) forward / inverse kinematics to move the stones,
(3) image processing to identify the game board,
(4) artificial intelligence to compete with human.

2.1 Robot Arm Control

The Lynxmotion AL5D [1] type of robot arm was used. This device is composed of a rotatory base, a single plane shoulder, elbow and wrist and an adjustable gripper. The size of the whole robot does not exceed 60 cm.

All the motors on the robot are controlled with the servo controller Lynxmotion SSC-32. A serial line is used for data transfer between a personal computer and the SSC-32. The basic protocol structure is as following:

[1] http://www.lynxmotion.com/c-130-al5d.aspx

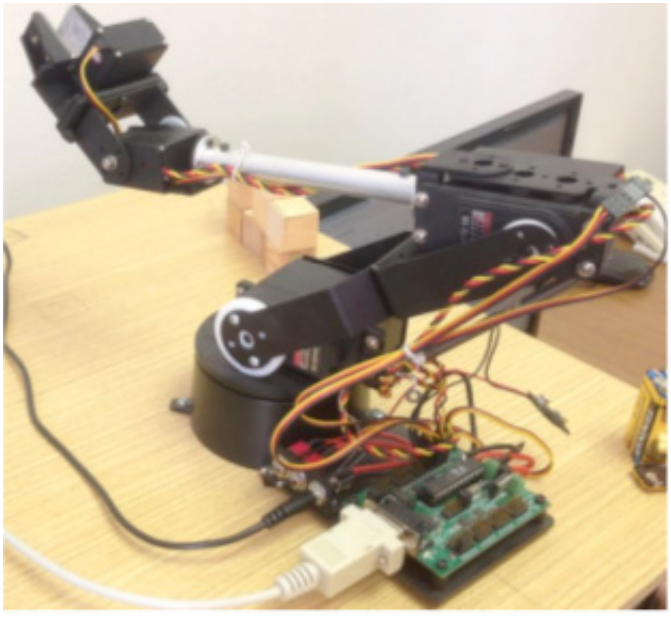

Fig. 1. Robot Arm AL5D