AC 2011-950: ROBOTICS AUTOMATION CURRICULUM DEVELOPMENT: FROM OPERATION AND PROGRAMMING TO THE VISION SYSTEMS

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Abstract

Robots are used in vast and continually growing number of industrial fields. Global competition, productivity demands, and advances in technology and affordability will force companies to increase use of the robots in the foreseeable future. Robots are artificial but very valuable helpers due to the fact that they assist humans in unsafe, unpleasant, repetitive, or high-precision work. In addition to the 1.1 million industrial robots operating worldwide, between 2009 and 2012, almost 50,000 units of professional service robots will be sold. Intense involvement of robots and integrated robotics platforms in different fields of industry, as well as in our everyday life, requires human-specialists with an up-to-date knowledge to maintain and monitor existing robots and to develop new, more advanced, smart, and safe technologies. As a result, educational institutions have to adequately respond to the high demand for specialists in the field of robotic automation by developing and offering robotic automation-related courses that lead to properly trained and certified workers. Very few universities across United States offer a degree and/or certification specifically in robotic automation. The curriculum development model described in this paper covers all the theoretical and practical aspects of the knowledge database required for technologists involved in the robotic automation industry. Unlike most robotic programs that focus on design, engineering, and fabrication - the described in this paper teaching methodology, fills an industrial need by focusing on implementation, improvement, and sustainability of the technology used in the manufacturing and maintenance of robots. The cross-disciplinary robotic automation training program presented here is very versatile. It is structured in a way to accommodate the needs of enrolled in the Michigan Technological University students, employees of industry looking to improve their knowledge in robotics automation areas, as well as students from another universities and colleges. So far, the developed "Robotics Automation" 4 credit hours course has been offered twice. The first offering was conducted in a semester long, and the second one in the intense 2 weeks mode. Each offering included extensive hands-on experience. A significant part of this course is devoted to introducing the basics of programming industrial robots using the ROBOGUIDE software package. After receiving sufficient off-line programming training, students implement their knowledge and perform laboratory experiments programming and operating a state-of-art LR Mate Fanuc Robotics' educational robotic platform. Upon successful completion of all the course requirements students receive FANUC Robotics industrial certificate in robotics and automation. Total, 14 students involved in these courses, received FANUC certificates. To provide additional flexibility in the course offering, the on-line version of the course is underway.

Introduction

Robots are widely used in manufacturing, assembly and packing, transport, earth and space exploration, surgery, weaponry, laboratory research, safety, and mass production of consumer and industrial goods. Robots play significant roles in our personal life as well by serving humans and performing everyday tasks such as cleaning, cooking, repairing, etc. Intense involvement of these artificial helpers in everyday life requires human-specialists with up-to-date knowledge to

maintain and monitor existing robots, as well as to develop new, more advanced, smart, and safe machines. During the last decade, popular interest in educational exploitation has increased significantly[1,3]. Robotics in education is seen as an interdisciplinary, project-based learning activity drawn mostly on math, science, and technology and offering major new benefits in education at all levels[2,4,5]. Some specialized robotics jobs require new skills, such as those of robot installer and robot integrator. While universities have long included robotics research in their curricular offerings and tech schools have taught industrial robotic arm control, new college programs in applied mobile robots are under development at universities in both the United States and Europe, with help from Microsoft, FANUC Robotics America Inc., MobileRobots Inc., and other companies encouraging the growth of robotics. Robotics is a naturally compelling subject for engineering, engineering technology, and computer science undergraduates, but never more so than when coupled with hands-on lab work.

Undergraduate study of robotics is fairly common, although few universities offer specific robotics degrees or certificates. For instance, Worcester Polytechnic Institute (WPI) offers a Bachelor of Science in Robotics Engineering. Universities that have graduate degrees focused on robotics include Carnegie Mellon University, MIT, UPENN, UCLA, WPI and the South Dakota School of Mines and Technology (SDSMT). Academic programs in the School of Technology at the Michigan Technological University are designed to prepare technical and/or management-oriented professionals for employment in industry, education, government, and business. The School of Technology's educational programs include significant hands-on laboratory components to prepare students for practical design and production work. To effectively meet the next generation's workforce needs, the electrical and computer engineering technology undergraduate curriculum must be up-to-date and relevant[6].

Robotics Automation Training Program

The cross-disciplinary robotics automation training program described in this paper was deployed by the authors in 2009[7]. The program is structured to accommodate the needs of enrolled in the Michigan Tech students, employees of industry looking to improve their knowledge in robotics automation areas, as well as students from another universities and colleges. We strive to achieve this goal by implementing new teaching techniques, modifying the course content to stay current with industry requirements, and employing different models of the class offering.

Robotics automation training program was developing rapidly and very efficiently[6,7]. Table 1 summarizes all the development stages the program has undergone since spring of 2009.

Year	Semester	Robotics Automation Training Program Status
2009	Spring	- Industrial collaboration: Contract with FANUC Robotics Inc. - Purchased 2 LR Mate Fanuc Educational Training Carts MH1.
2009	Summer	- Faculty on-line training for FANUC Robotics Material Handling Pro. - Faculty on-site training for FANUC Robotics Material Handling Pro. - Faculty certification for FANUC Robotics Material Handling Pro.
2009	Fall	- "Robotics Automation" 4 credit hour course development.
2010	Spring	- First offering (semester long mode): "Robotics Automation" 4 credit hours course.

2010	Summer	- Second offering (2 weeks intense mode): "Robotics Automation" 4 credit hours course. - Faculty on-line training for FANUC Robotics V-iRVision Operation and Programming-2D. - Faculty on-site training for FANUC Robotics V-iRVision Operation and Programming-2D. - Faculty certification for FANUC Robotics V-iRVision Operation and Programming-2D.
2010	Fall	- Preparing on-line version of "Robotics Automation" 4 credit hours course.
2011	Spring	- Third offering (semester long mixed (on-line and in-person) mode): "Robotics Automation" 4 credit hours course.
2011	Summer	- Fourth offering (2 weeks intense mixed (on-line and in-person) mode): "Robotics Automation" 4 credit hours course. - Development "Robotics Vision" certification course.

In spring of 2009 industrial collaboration with FANUC Robotics America, Inc., the leading supplier of robotic automation in the Americas was established. Over 200,000 FANUC robots are installed worldwide, and more than 200 robot variations work in a wide range of applications including assembly, material removal, material handling (machine tending, picking, packing, and palletizing), painting, dispensing, and welding. Robotic automation is on the leading edge of manufacturing today and FANUC Robotics is the industry leader. FANUC has established Robotics Certified Education Robot Training Program. The mission of the FANUC Robotics Certified Education Robot Training (CERT) Program is to create Certified Education Robot Training that promotes an understanding of FANUC Robotics' robotic automation solutions through the development and implementation of integrated classroom instruction and student projects. The Certified Education Robot Training (CERT) program is a new certification available to qualified universities. The program certifies instructors at educational institutions to train their students to program FANUC robots. To accompany the CERT program, FANUC robotics provides a new innovative educational tooling package that includes an industrial robot, integrated vision system, and ROBOGUIDE simulation software.

In summer 2009, Dr. Sergeyev completed multiple online training sessions as well as on-site training. Online training required attending and passing the following online courses: The Robot Operations, HandlingTool Operations and Programming, Online HandlingPRO, Online Advanced HandlingTool Operations and Programming Certification. Upon successful completion of web-based courses, the involved faculty required to attend and successfully pass a live HandlingTool Operations and Programming class as a student at FANUC's facility. After all the requirements were completed, Dr. Sergeyev became certified by FANUC as an instructor to teach robotics-related courses and to issue the FANUC Robotics certificate.

In fall 2009 "Robotics Automation" 4 credit hour course was developed. Course consists of recitations conducted 3 times a week, multiple simulation projects utilizing FANUC ROBOGUIDE software package, and 3 hour laboratory exercises straightening expertise working with real robots. The course is suitable for the students working towards their bachelor's

degree as well as students interested in obtaining an industrial certificate in robotics[6]. Featuring a careful balance of theory and application techniques, the students learn how to design and build a robot-driven automated work cell - from selection of hardware through programming of the devices to economic justification of the project. Designed from a manufacturing perspective, it not only addresses robots in an isolated manner, but also explores the broad topic of industrial work cells that contain a robot including robot automation and all related technology needed in the automated work cell to integrate the robot with the work environment and with the enterprise database. A significant part of this course is devoted to introducing the basics of programming industrial robots using the ROBOGUIDE software package. Within the shell of this powerful simulation tool, the student learn the structure of the programming language commonly used in the field of robotics, get familiar with the HandlingTool software installed on the physical controller of LR Mate Fanuc robotics' mini robot, and learn to perform off-line programming. After receiving sufficient off-line programming training and passing the safety-related test, students are ready to implement their knowledge and perform laboratory experiments programming and operating a state-of-art LR Mate Fanuc robotics' educational mini robot platform. Lab work is structured in teams of two-to-three students in order to foster collaboration and ease some of the challenges and frustrations inherent to working with physical hardware.

In spring 2010, the course "Robotics Automation" course was offered for the first time with eight enrolled students. The course was conducted during the entire semester and included 42 lectures, 6 simulation projects, and 10 laboratory exercises. The student's progress was assessed with 13 quizzes, midterm, final and certification exams. Ninety percent of the students completed the course with the score 93/100 and higher. Within the remaining 10% of the student body, the lowest score was 88/100.

In summer 2010, an accelerated version of "Robotics Automation" course was offered for the first time with six enrolled students. The course material, including simulation and laboratory assignment, was delivered during 2 weeks totaling 80 contact hours. Every day students had total of 4 hours of recitations, 1 simulation project and 2 laboratory exercises. The progress was assessed daily with quizzes and with midterm exam at the end of the first week. At the end of the second week all participants were required to successfully pass the cumulative certification exam with the passing score of at least 80/100. All participants successfully fulfilled all the course requirements and received FANUC Robotics' certification. Also, ***in summer 2010***, Dr. Sergeyev became a certified instructor in FANUC Robotics V-iRVision Operation and Programming-2D.

In order to attract industry representative and students from the other universities and colleges, ***in fall of 2010***, authors initiated the development of on-line version of the "Robotics Automation" course. The main idea behind the on-line version of the course was to create readily available on-line learning materials: Echo-360 recorded lectures and simulation assignments vie remote access.
Currently the "Robotics Automation" course is offered in the semester long mode and the idea of on-line offering is partially integrated by providing the students with traditional methods of teaching as well as using on-line developed learning modules. In this semester, the course is structured to have 60 to 40 percent assortments of in-person lectures and on-line learning modulus. All the quizzes, midterm and final examinations are conducted via blackboard.

In summer 2011, the "Robotics Automation" course will be offered again in the 2 weeks accelerated mode but with all learning modules and simulations assignments and assessments available on-line. During the last four days of the course the students will perform hands-on activities completing all the laboratory assignment.

Facilities – Robotics Laboratory

The School of Technology at the Michigan Tech offers high-quality, up-to-date academic programs that endeavor to meet the immediate and future needs of industry. The Michigan Tech strategic plan calls for us to be nationally recognized for programs that advance technological education through excellence in learning, discovery, and engagement. While we are a technology program, we go beyond most other technology programs by offering significant hands-on lab experiences and applied research opportunities to undergraduates. These experiences complement the classroom experience and prepare our students for careers in a wide range of industries.

The Electrical Engineering Technology program has identified present needs for a new state-of-the-art robotics laboratory, that will support a "Robotics Automation" course and provide students with training that meets industrial standards and provides state-of-the-art, hands-on training. Currently, the laboratory is equipped with two robotic stations and supports the class size of 12 students. It is our goal to equip the laboratory with at least 6 robotic stations to comfortably accommodate a class of 30 students. A single robotic station consists of a LR Mate FANUC Robotics educational mini robot platform, shown in Figure 1, a single phase R-30iA Mate controller, and a high-end computer with installed ROBOUGIDE software package to be used for off-line training, programming, and modeling.

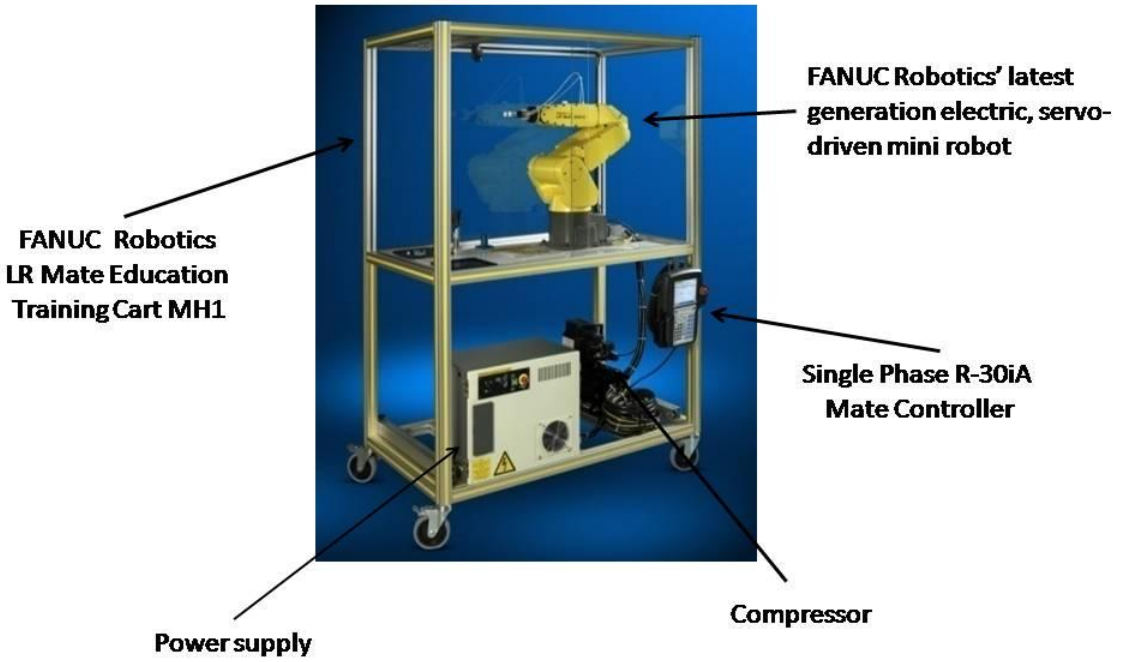

Figure 1: The FANUC Robotics LR Mate Education Training Cart MH1; incorporating FANUC Robotics' latest generation electric, servo-driven mini robot and housed in a self-contained, portable enclosure. The figure also shows the location of the power supply, the compressor, and the single phase LR Mate controller.

Conclusion

Academic programs in the School of Technology at Michigan Tech are designed to prepare technical and/or management-oriented professionals for employment in industry, education, government, and business. The development of new robotics-related courses and a robotics laboratory will promote robotics education and create significant impact on education in the School of Technology and Michigan Tech as whole. By strengthening the robotics area, the proposed program will improve the quality of STEM education for undergraduate students by creating innovative learning material and teaching strategies and by implementing advanced, hands-on expertise valuable to industry. The professional development of involved faculty members will be advanced through extensive training and industrial certification in the field of robotics and automation provided by FANUC Robotics America Inc. This partnership creates an important link between academia and industry. The appealing nature of the robotics will be used in our outreach efforts to trigger an interest among the students of the local middle and high schools.

The robotics curriculum development will advance undergraduate research within the School of Technology, promoting robotics-related senior design projects and allowing the students to participate in national and international robotics competitions. The state-of-the-art robotics

laboratory will also be capable of demonstrating the current advances in the area of robotics during department open house and visits, and will certainly serve as eye-catching demonstration during recruiting and "show and tell" events. Our strategy of offering the "Robotics Automation" course on demand and in the semester as well as in accelerated modes will allow not only the Michigan Tech students but also the industry representatives and students from the other universities and colleges enroll at their own convenience.
The robotics area will advance undergraduate research within School of Technology, fostering enhanced robotics-related senior design projects and allowing the students to participate in national and international robotics competitions. Such an approach to the education of engineering technology students meets the expectations of ABET accreditation standards by connecting students to the solution of real problems.

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