

Mechatronics Capacity Building in Tanzania

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Abstract

The paper deals with a capacity building project carried out by Politecnico di Milano and the three main technical universities of Tanzania aimed at stimulating high education in mechatronics and at giving professors the tools to design new mechatronics courses in the universities of the Country. This work is focused on the activities carried out at Mbeya University of Science and Technology (M.U.S.T.) where, within one week of intensive course, Tanzanian professors had the opportunity to develop a mechatronic system. The approach was aimed not just at teaching main subjects of a mechatronics course, but also at suggesting how these courses could involve university students on topics that will be a challenge for the emerging industry of the country.

Keywords: *Mechatronics, Robotic, Capacity Building.*



A. INTRODUCTION

Starting from an official request of the government of the United Republic of Tanzania to support the technical education sector, the Italian government approved the implementation of a programme [3] focused on the following objectives, expanding access to academic engineering programmes and improving the quality of teaching and learning through training courses dedicated to staff, developing new engineering programmes that can better satisfy the demands of the local industrial market, increasing partnerships and ties with the industries through student placement services and continuous professional training, increasing women participation in engineering courses and employment in careers connected to technical studies. Politecnico di Milano was in charge of capacity building training courses.

The first phase of the project was dedicated to the assessment of existing curricula and was conducted through an initial fact-finding mission. This phase served both to identify critical issues with regard to improvements in terms of quality, relevance and effectiveness and to establish specific designated areas of interest in terms of developing curricula. Mechatronics was among the designated areas of interest. The initial analysis also served as a means of producing an assessment of the Tanzanian academic system in the engineering area, a specific overview of the three Tanzanian universities involved, and a market analysis to reduce the gap between academic curricula and the expertise demanded by the labour market. On completion of the assessment phase, capacity building was developed in three distinct stages. The first

phase involved a one-week visit to Politecnico di Milano by a delegation of high-level representatives from each of the three universities in Tanzania, including the rectors of the three institutes. The purpose of this visit was to show the study and learning methods and programmes used at Politecnico di Milano, the main strategic research lines and the mechanisms on which cooperation between a technical university and industries are based. The second phase of capacity building consisted in three weeks of training at Politecnico di Milano for professors, researchers and administrative staff from the Tanzanian universities involved (six from was shown the way Politecnico di Milano works to build relationships with both Italian and international industries).

In parallel, visits and meetings were organized for the administrative staff, who had the opportunity to get to know the offices of Politecnico that provide services dedicated to teaching, research and relations with industry. The third phase is that discussed in this paper and regards the provision of intensive courses at the three Tanzanian universities through a week-long course attended by twelve people from the three universities in Tanzania. programme characterized by strong ties between universities and businesses, which had been absent in Tanzania's universities. In addition, the updated curricula have helped to improve the teaching systems of the universities, thus fostering the general development of the local university system. Specifically, through this project Politecnico di Milano has contributed to enhancing academic management and curricula both in academic terms and in terms of relations with local and international enterprises.

The paper is structured as follows. Section 2 introduces the aim and the objectives of the intensive course on mechatronics carried out at Mbeya University of Science and Technology (M.U.S.T.). Section 3 gives an overview of theoretical background on mechatronics, while section 4 is focused on experimental activity. Results of the course have been presented to students of secondary schools in an open-day activity (Sec.5). Attenders' evaluation is discussed in Section 6 and conclusions are drawn in Section 7.

For this reason the course has been developed with a mix of lectures and laboratory activities. Being mechatronics multidisciplinary by its nature, the course has been structured to account for mechanics, electronics and information technology/control taking into account the tight time constraint of one week. To motivate the audience, a relevant example that helped the teaching on all these different aspects has been chosen. In particular the development of a parallel kinematic manipulator on the well-known structure of the robot delta has been taken into account. During the week, participants were faced with the technical and theoretical concepts to develop the device and to control it properly. Lectures were held in plenary mode.

B. LITERATURE REVIEW

The starting point of the design of any mechanical and mechatronic system is the analysis of the required tasks. This requires some basics on kinematics to carry out the synthesis of a trajectory and the definition of a motion law, as well as some knowledge on dynamics to estimate forces and torques applied on the system and evaluate gear-motors behaviour. Considering a robot, it means being able to design a trajectory in the workspace and to associate it with a law of motion, (ie. a velocity profile and acceleration) and to transpose these information to joint space, (ie. Defining the laws of motion of each motor to achieve the desired movement) through the inverse kinematics. Topics of motion planning have been discussed, highlighting the effects of the law of motion on the dynamics of a system [6].

Participants have the opportunity to write some simple algorithm to manage fundamental motion laws and to create complex movements. Analysis are carried out with Octave: the choice to use a free software ensures this tool can be used by participants in their universities even after the end of the course. Once the motion has been designed, it is necessary to assess the system dynamics, by estimating both forces and torques acting on the system so as the contribution that each motor should exert. The dynamic analysis for a simple systems can be conducted by means of analytical models and allows to evaluate the expected performance and main limitations (eg. motor torques too high), or possible improvements.

The ability to calculate and to monitor the main kinematic and dynamic parameters, allows to optimize the performance of a machine. This type of analysis is crucial from an industrial point of view as, for example, it allows to ensure high precision, to maximize the production or to avoid overloads. Participants are divided into three groups and are asked to develop a software that is able to synthesize a trajectory and the corresponding motion curve, to perform the inverse kinematics and to check that the task is compatible with the performance and the geometry of the robot. Figures 3, 4 show the numerical analysis done by a group. The graphs in Fig.4 show the main kinematic and dynamic quantities related to the trajectory shown in the figure above.

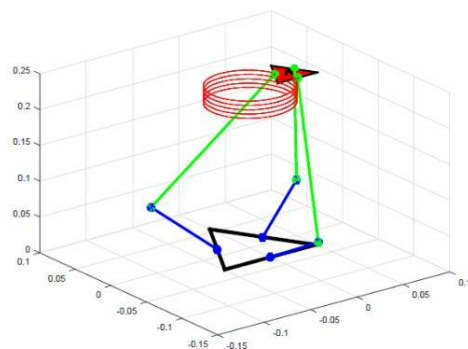


Figure 1 Desired Trajectory in Space

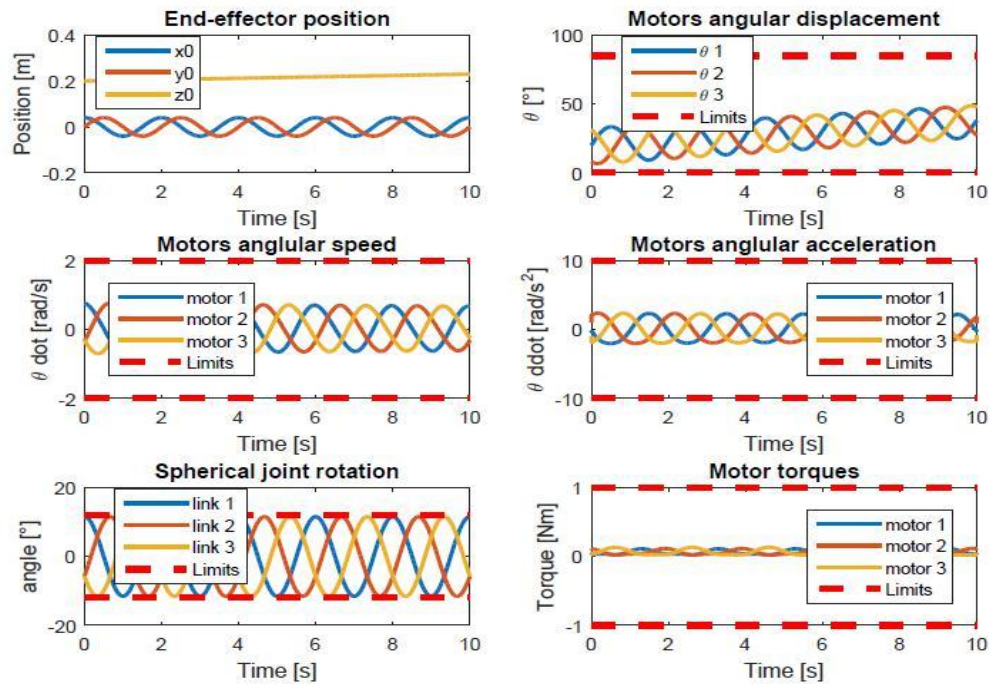


Figure 2 Numerical Evaluations of Kinematics and Dynamics

The last lecture is dedicated to the control of a mechatronic system. Basics of control are discussed as feedback versus feed forward, different types of controllers, concept of stability and performance indexes of a controlled system. The lecture is accompanied by a short introductory seminar on Arduino, an open-source electronics platform based on easy-to-use hardware and software. Arduino is a good opportunity for the development of low cost mechatronic systems and is widely used in universities to give students the opportunity to put into practice the theoretical knowledge acquired in control courses.

C. METHOD

During the final day of the course, the Tanzanian researchers and professors had the opportunity to show their work at the university open day. The last year students of secondary schools in the area were invited to the event together with the university students involved in the Mechatronics course. The participants were over 300, especially thanks to the support of the local administration and the Italian Embassy that organized the transport from secondary schools to the M.U.S.T. The open day was organized with an initial greeting by the Rector of M.U.S.T., Professor J. J. Msambichaka, and the delegate of the Italian Embassy that funded the capacity building project. With this opportunity, a video of the activities done during the project was projected, so that students would have the opportunity to appreciate the content of a mechatronics course, but also the potential and the innovative aspects that this discipline offers especially in the industrial field. A reduced version of the video is

available in then, the 12 participants of the intensive course showed their work. The students' curiosity and interest stimulated the participants and gave them an immediate feedback on the work they did. Moreover, to encourage the active participation and to stimulate interest, students were given the opportunity to test the manipulator their selves and to tell their mates their own experience. The explanation was made in native language and was very engaging both for speakers and audiences, reaching the aim of stimulating secondary school students to higher education. At the end of the intensive capacity building course, participants had the opportunity to evaluate the course and suggest any improvements. Participants were given a questionnaire to evaluate their satisfaction.

D. CONCLUSION

The capacity building activity at M.U.S.T. was addressed to future professors of mechatronics courses of the three main technical universities in Tanzania. The intensive course was very engaging for both the participants and the trainers and allowed to frame the main themes that could be addressed in a mechatronics course highlighting the multidisciplinary nature of the subject. The course was therefore carried out with the spirit of transmitting a vision of mechatronics, without pretending to cover all the facets, but rather suggesting a way in which such a course could be done. The opportunity to extend this vision to college and high schools students in a dedicated open-day has also allowed a direct involvement of future students, stimulating them on a theme that will be of great interest to the future development of the emerging industrial reality of Tanzania.

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