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Multidisciplinary Approach and Dual Education in Control Engineering for Mechatronics

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Abstract: Dual education is an effective integration of control theory and practical experience providing ideal start to improve professional career of students at many technical universities. The most important benefits it brings both students and industrial partners are practical training in industry companies, opportunity to acquire practical to skills on modern industrial plants and production equipment, as well as to feel how it is to be employed or learn what are the requirements and the culture of companies. At the same time, students have a great chance to be offered a job still during their studies. The paper presents the modern form of study with the focus on development of control methods, control structures, ICT, and their applications in different types of industrial processes. Since its emergence in the late 1970s, mechatronics has become well-established as an academic subject, and is now researched and taught at a large number of worldwide universities and research institutions. We try to get to the heart of multidisciplinary engineering of which mechatronics is an excellent example, and point out how the integration of disciplines leads to new degrees of freedom in the corresponding dual form of education in connection with industrial partners.

Keywords: automation, mechatronics, information technology, communication technology, control engineering, education

1. INTRODUCTION

During the last years, working groups closely co-operating with the practice have been established at leading world universities. High production quality cannot be achieved without development and application of new mechatronic methods and systems based on recent technologies in electronics, mechanics, control, electrical equipment and ICT. Many industrial processes and consumer electronic products have incorporated advanced control methods, micro-processors, programmable logic controllers and computers to enable and embed intelligence and more functionality in them. Multidisciplinary engineering systems have electronics, computers, and control as integral parts. Performance, reliability, low cost, robustness, and sustainability are absolutely essential. Mechatronics integrates the fields (Isermann, 2008) of mechanical, electrical, control, and computer engineering; this concentration was created because knowledge across these disciplines is essential to improve and/or optimize the functionality of modern engineering systems. Mechatronic engineering is one of the youngest engineering disciplines. It brings together mechanical, electrical, electronic and computer engineering: the essential part of the discipline is the integration of machines and systems (Tomizuka, 2002). involving these elements.

The principal characteristic of the dominant branches is as follows:

• Mechatronics is the engineering discipline integrating technologies from mechanical engineering, electronics, and computing to create more intelligent devices and machines (Fig. 1).
• Informatics is the science of processing data for storage and retrieval; a successful design of complex systems is highly dependent on how design information is represented, managed and retrieved.
• Automation – Control engineering concerns the design of process controllers based on understanding dynamic characteristics so that the process behaves in a desirable way.

Traditionally, mechatronics has been applied to manufacturing and other industrial automation: robotic automation found in automated car production lines such as welding, and assembly lines in computer-integrated manufactures. These mechatronic applications have been extended from industrial systems to domestic products. New products have been designed applying mechatronic principles; consumers and society have benefited tremendously from these new intelligent products including the latest mobile phones with mechatronic features, intelligent robotic vacuum cleaners and intelligent wheelchairs. Well-known and well-established mechatronics systems include production systems, synergy drives, automated guided vehicles, automotive subsystems such as antilock braking systems, and commonly used spin-assist consumer products such as auto-focus cameras, hard disk drives, compact disc players, and washing machines. The

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main benefits that mechatronics has provided are increased functionality and comfort level, energy savings, versatility, and flexibility.

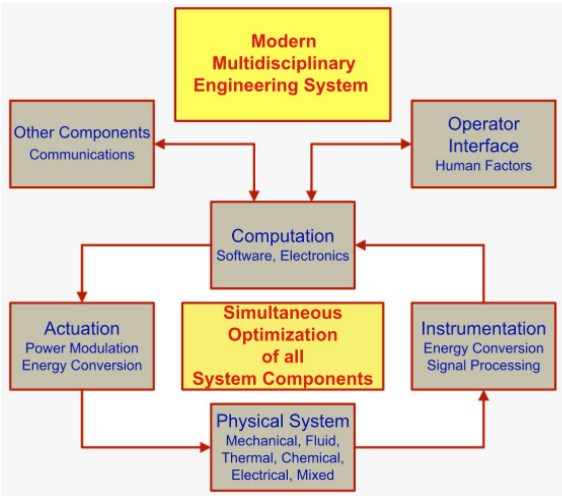

Fig.1. Mechatronics Multidisciplinary System

Research and education in mechatronics focus on the fusion of mechanical and electrical disciplines in modern engineering processes aimed at achieving a cost-effective, optimal balance between mechanical structure and their overall control (Fig. 2). Research in Automation and Mechatronics varies from fundamental research in control engineering theory to the conception, design, and prototype applications to automation. Research topics in this area include active and passive damping, adaptive learning and predictive, optimal and robust control of systems with uncertainty, automated manufacturing and remanufacturing, fuzzy and neural networks for control and identification, precision engineering and motion control, multimedia technology, intelligent sensors and actuators, vision-based motion control, and teleoperation.

2. ADVANCES IN AUTOMATION AND MECHATRONICS

Systematic approach and several advanced software design tools are required during the design of a mechatronic system. The mechatronic design is an iterative and integrated process that includes different kinds of the domain-specific engineering (e.g. mechanical, electrical, electronic, information, automation, and multidisciplinary) for a successful design, implementation, and inspecting. The design step is the starting and most important procedure, and for the design aspects, system of objectives, applications, requirements, functions, active structure and shape, and behavior should be considered. The implementation and inspecting step include distribution of interdisciplinary tasks, use of sensors and actuators, electronic architecture, software architecture, different controllers design (PID, LQ, MPC, etc.) and system validation (Kozák, 2012) resulting in totally desired functions. The development scheme is represented in the form of a V-model, which distinguishes between the mechatronic system design and integration as shown in Fig. 2 and Fig. 3.

A control system and control engineering methods are at the heart of mechatronic systems where electronics are used to control mechanical systems.

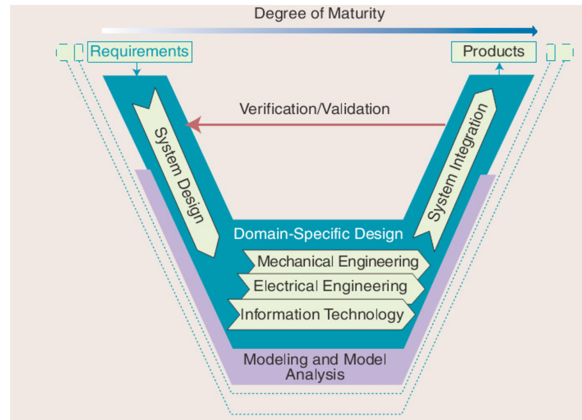

Fig.2. V– model of mechatronic subsystems integration

Research and education in control systems have a long history of mathematical rigor with application to diverse branches of science and engineering. Control methods, algorithms, and tools developed by control researchers have been widely used by generations of engineers to solve problems of practical importance with enormous impact on society. Control concepts (Isermann, (2008) have been crucial in the design and development of high-performance mechatronic systems (airplanes, fuel-efficient automobiles, industrial process plants, manufacturing enterprises, smart phones, planetary rovers, communication networks), and many other applications across various sectors of industry.

As automation and intelligence are essential for mechatronic systems, the importance of sensors of mechatronic systems to meet the needs has grown steadily. An intelligent mechatronic system should be supported by various sensing devices (Fig. 3). Various sensors (e.g. potentiometers, encoders, proximate switches, tachometers, acceleration sensors, and gyro sensors) have been used in mechatronic systems such as robot systems, manufacturing systems, automotive vehicle systems, and aircraft vehicle systems.

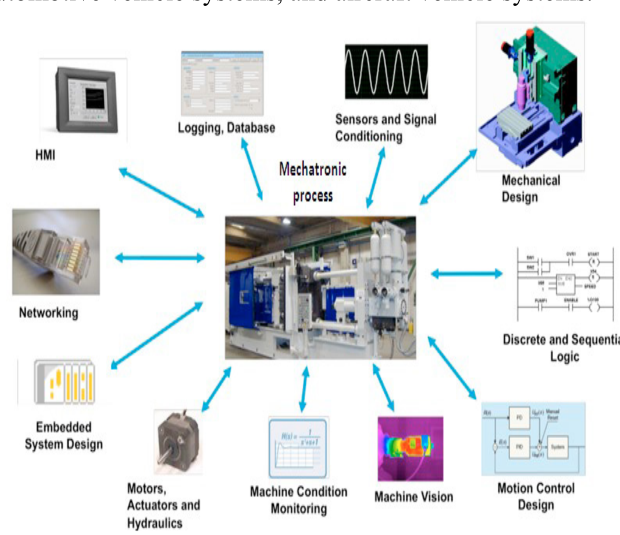

Fig. 3. Integration of the process elements into complex mechatronics systems