International Journal
Information Technology Applications (ITA)

Volume 12, Number 2, December 2023

AUTOMATION – INFORMATICS – COMMUNICATION – ARTIFICIAL INTELLIGENCE, PAST, PRESENT AND FUTURE

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Abstract:

The paper presents state-of-the-art of the research, development of advanced control methods, control structures, information a communications technologies AI and their applications to the different types of industrial processes, health care, services. In this paper we analyse methodology and basic common principle of four close field scientific discipline automation, information, communications technologies, and mechatronics. Automation, IKT, AI and Mechatronics is becoming an increasingly important discipline in today's digital society. Automation technology is understood to be the use of such methods, control strategies, processes, and installations (hardware and software) which can fulfil defined objectives without the constant interference of man in a largely independent manner, i. e. automatically. Mechatronics integrates the fields 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. Motivated by the practical success of control engineering methods in consumer mechatronics products and industrial process control, there has been an increasing amount of work on development of new methods which are based on new robust, adaptive, effective numerical optimization techniques, soft computing strategies, and hardware realization of control algorithms using embedded controllers and FPGA circuits for fast dynamic processes.

Keywords:

Automation, information technology, communication technology, control engineering, PID controller, MPC controller, fuzzy sets, neural networks.

Introduction

Many industrial processes and consumer electronic products have incorporated advance control methods, microprocessors, programmable logic controllers and computers to enable and embed intelligence and more functionality in these systems. Mechatronics integrates the fields 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. The principal characteristics of the following dominant branches:

- Mechatronics is the engineering discipline of integrating technologies from mechanical engineering, electronics, and computing to create more intelligent devices and machines. (Fig.1a,b)
- Informatics is the science of processing data for storage and retrieval. The 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 an understanding of dynamic characteristics, so that the process will behave in a desirable way.

Traditionally, mechatronics has been applied to manufacturing and other industrial automation: robotic automation found in car automated production lines, such as welding and assembly lines in computer-integrated manufacture. These mechatronic applications have been extended from industrial systems to domestic products. New products have been designed applying mechatronic principles and increasingly 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. Mechatronics has contributed to progress in many industrial fields such as robotics, semiconductors, aerospace, automotive, consumer electronics, and medical. Well-known and well-established mechatronic 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 main benefits that mechatronics has provided are an increased functionality and comfort level, energy savings, versatility, and flexibility.

Research in automation and mechatronics focuses 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 the Automation and Mechatronics area varies from fundamental research in control engineering theory to the conception, design, and prototype evaluation of innovative mechatronic systems and 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 acutators, vision-based motion control and teleoperation.

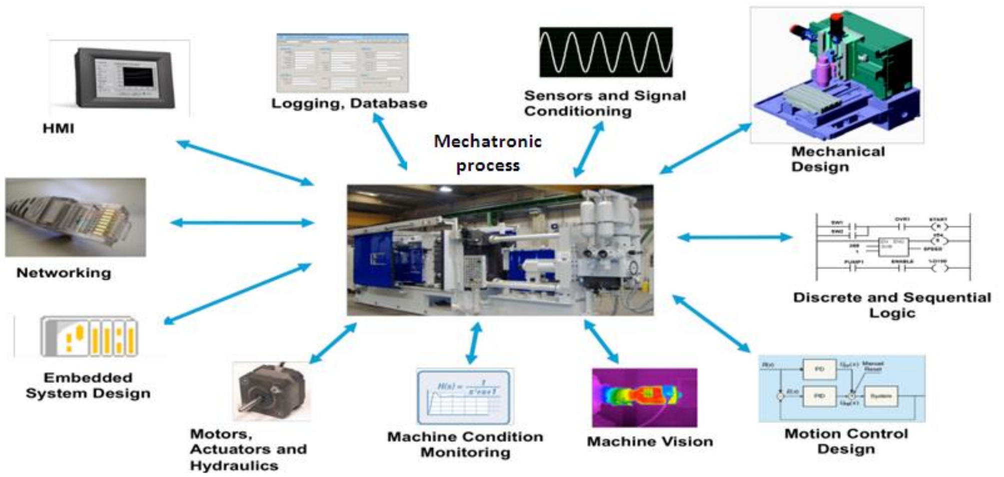

Fig.1a. Synergic connection of some important fields in effective complex mechatronics system design.

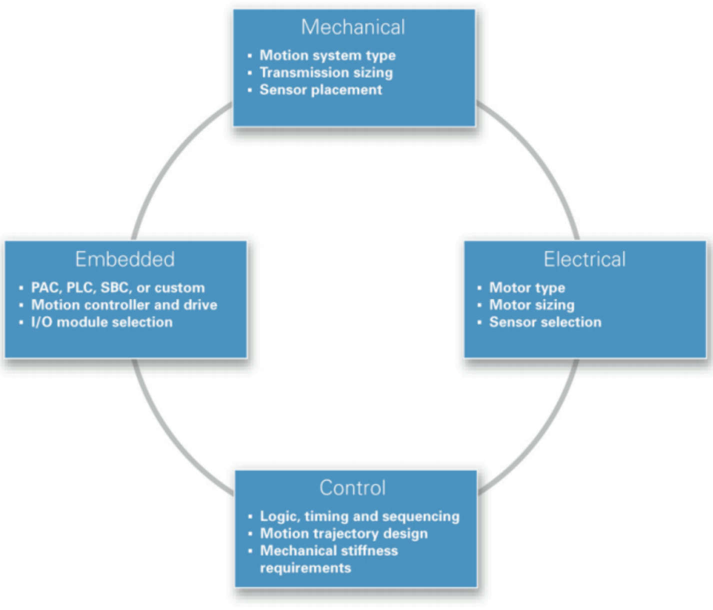

Fig.1b. Synergic connection of some important fields in effective complex mechatronics system design.

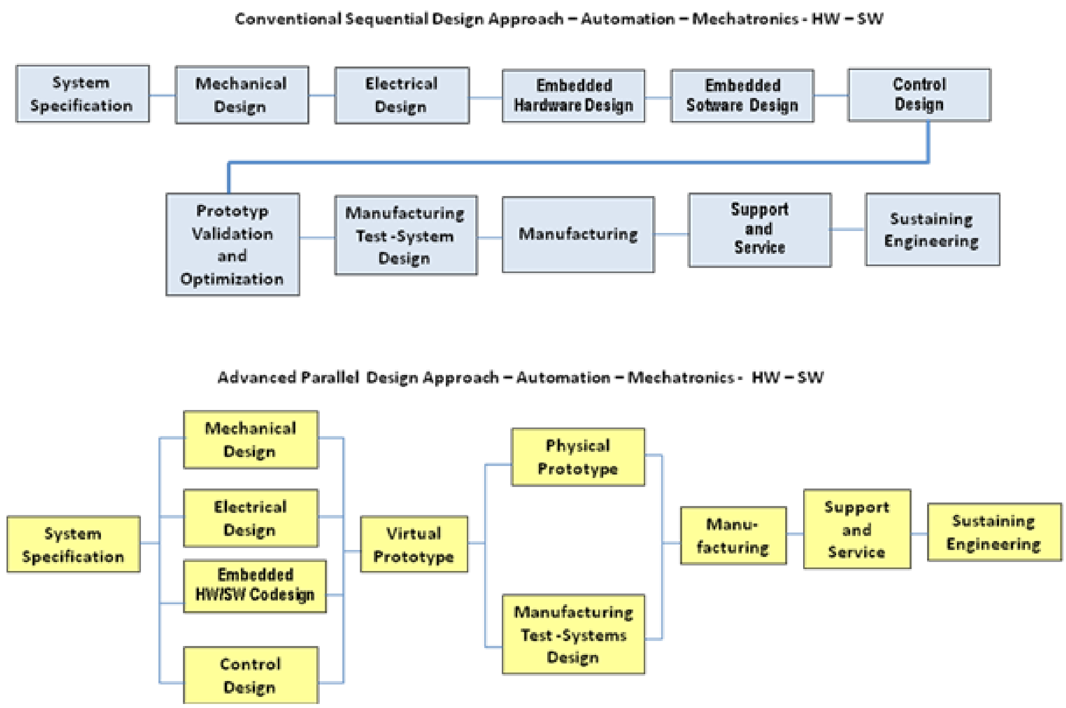

Fig.2. Conventional and advanced structures of mechatronic systems development.

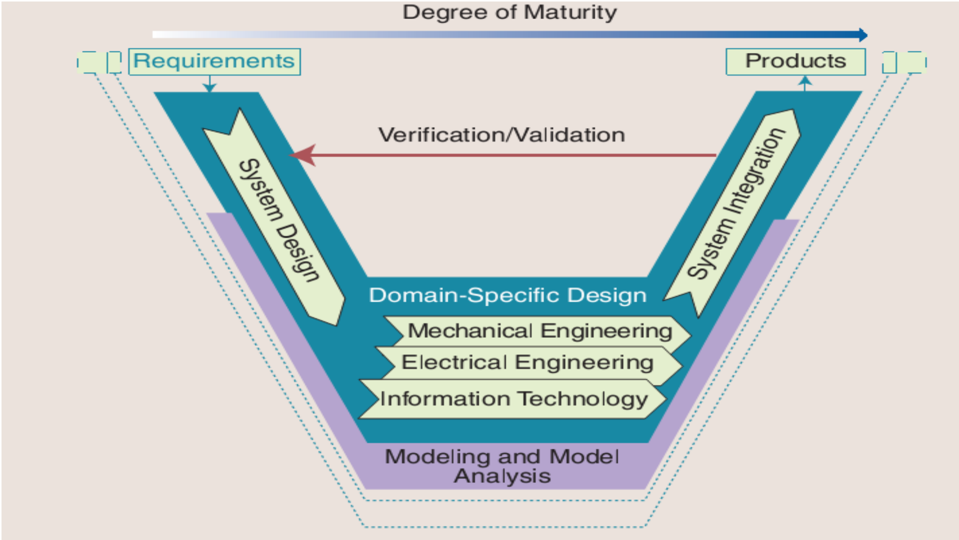

Fig.3. V-model scheme for development of mechatronic systems.

1 Advances in Automation and Mechatronics

Mechatronics systemic progress and several advanced software design tools are required during the design of mechatronic systems. 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 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 the distribution of interdisciplinary task, the use of sensors and actuators, the electronic architecture, the software architecture, the different controller design (PID, LQ, MPC, etc) and system validation resulting in totally desired functions. The development scheme is represented in the form of a V-model, which distinguishes between the mechatronics 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. Control systems research has a long history of mathematical rigor, with application to diverse branches of science and engineering. The 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 have been crucial in the design and development of high-performance mechatronics 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. In these and other complex engineering systems, control theory and its technological artifacts are also widely used to ensure reliable, efficient, and cost-effective operations.

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. Various sensors (e.g., potentiometers, encoders, proximate switch, tachometers, acceleration sensors, and gyro sensors) have been used in mechatronic systems such as a robot system, manufacturing system, automotive vehicle system and aircraft vehicle system.

Because of the advances of manufacturing, sensor technologies, and micro/nanotechnologies, more compact (micro/nanosize) and highly integrated mechatronic systems have been recently created. Since redundant sensory information is installed/designed in systems, doubt never arises about implementing multisensor fusion methods into smart mechatronic systems and hence results in more intelligent performances. The challenges and perspectives of advanced mechatronics are summarized as the key directions in research and applications in automation and mechatronics:

- intelligent mechatronics, vehicles, robotics, biomimetics, automation and control systems,
- opto-electronic elements and materials, laser technology and laser processing,
- elements, structures, mechanisms and applications of micro and nano technologies,
- teleoperation, telerobotics, haptics, and teleoperated semi-autonomous systems,
- sensor design, multi-sensor data fusion algorithms and wireless sensor networks,
- biomedical and rehabilitation engineering, prosthetics and artificial organs,
- control system modeling and simulation techniques and methodologies,
- AI, intelligent control, neuro-control, fuzzy control and their applications,
- industrial automation, process control, manufacturing process and automation.

The challenges and perspectives of mechatronics are summarized as shown in (Tab.1).

Conclusion

The need for increased performance in efficiency, productivity, and flexibility through automation is more than obvious. Automation, AI and Mechatronics has already improved existing products and developed new ones with better performance in other consumer and industrial areas and applications.

Automation, AI and robotics remain the key sciences of the 21st century because they bring forth all the comforts in life and solve many inconveniences. The challenges and future perspectives for the forthcoming applications and requests are described in this paper. Intelligent control engineering methods and structures have a wide spectrum and extend to other engineering sciences, such as the application of mechatronics, from the traditional to the high technical areas, such as car industry, medical areas, multisensor fusion, and micro/nano techniques application.

References

[1] R. Isermann: Mechatronic systems - Innovative products with embedded control, Control Eng. Practice, vol. 16, no. 1, pp. 14 - 29, Jan. 2008.

[2] R. C. Luo, C. C. Lai, and C. C. Hsiao: Enriched indoor environment map building using multisensor based fusion approach, inProc. IEEE Int. Conf. Intelligent Robots and Systems (IROS), 2010, pp. 2509 - 2064.

[3] S. Hutchinson, G. D. Hager, and P. I. Corke: A tutorial on visual servo control, IEEE Trans. Robot. Automat., vol. 12, no. 5, pp. 651 - 670, Oct. 1996.

[4] M. K. Habib: Mechatronics engineering the evolution, the needs and the challenges, in Proc. IECON 2006, pp. 4510 - 4515.

[5] R. C. Luo and C. C. Chang: Multisensor fusion and integration aspects to mechatronics, IEEE Ind. Electron. Mag., vol. 4, no. 2, pp. 20 - 27, June 2010.

[6] Š. Kozák: Advanced Control Engineering Methods in Modern Technological Applications. In: ICCC 2012 : Proceedings of 13th International Carpathian Control 2012, ISBN 978-1-4577-1866-3, pp. 392 - 397.

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