# Mechatronics—"What Is It, Why, and How?" An Editorial

***Abstract*— It is our great pleasure to welcome you to the new publication of the IEEE/ASME TRANSACTIONS ON MECHATRONICS. This TRANSACTIONS is published quarterly from this premiere issue in 1996 as a joint publication of the IEEE Industrial Electronics Society, the IEEE Robotics and Automation Society, and the ASME Dynamic Systems and Control Division, aiming at establishing a high-quality archival journal which represents *state of the art* of mechatronics, its recent advances, and practical applications. Many of you are quite familiar with the basic concepts and commercial products utilizing the control of mechanical systems in conjunction with modern electronics technology. The word "Mechatronics" is a new word for the blending of mechanics and electronics invented in Japan at the end of the 1960's. Yaskawa Electric Company once commercially registered the word "Mechatronics," which is now freely used by anyone [1]. In this editorial, we look back at the history of mechatronics, project it into the future, and state the scope and direction of this new journal.**

## Mechatronics in the 1970's

IN THE beginning of the 1970's, mechatronics was viewed as the combination of mechanics and electronics. There were many mechatronic products, such as automatic doors, vending machines, auto focusing cameras, automatic vehicle controls and so on. Mechatronics in those days was mostly concerned with servo technology for high performance. Therefore, mechatronics in the 1970's was rather simple, but it was also the dawn of advanced control methods.

## Mechatronics in the 1980's

In the 1980's, information technology was introduced. Microprocessors enhanced its capacities and subsequently were introduced into more sophisticated mechatronic products to improve their performance. NC machines and industrial robots which are typical mechatronic products were made more compact because of their innovative performance. Automotive motor control systems, for example, were popular mechatronic products. Microprocessors were introduced as the key technology in the vehicle systems. Mechano-electronics systems still widen their application in the vehicle systems successfully, such as height control, exhaust gas control, vibration control, traction cruise control, antibraking systems, air-bag systems, and so on.

There have been numerous novel innovations in the 1980's, such as using the intelligent control scheme. "Intelligent control" in this case, is viewed as an advanced control, which looks more intelligent than what is expected in an average performance. Information technology drove most mechanical systems more or less utilizing data base. Even washing machines and other consumer products were using database-driven systems, creating much wider applications. In these areas, systematic design methods were sought for mechatronics, and so the aspect of modeling and system integration was becoming more important as well as concurrent engineering design and control implementation. Furthermore, optics emerged with mechatronics, so that a new optomechatronics field was born.

## Mechatronics in the 1990's

In the 1990's, the field of mechatronics introduced communication technology that stands alone among conventional mechatronic products which are connected by a communication network to show higher performance in the global sense. This corresponds to the decentralization of the computer network. The machine can be controlled remotely, like the teleoperation in robotic systems. Computer-controlled networking mechatronics is getting more popular, often closely related to virtual reality and multimedia technologies. Some mechatronic machines have dual use and some have more than dual use in their performance. Therefore, mechatronics has a bright future and will grow steadily into the next century.

In particular, system integration has another viewpoint by combining micro sensor and actuator technologies, which is defined as "micro-mechatronics." Micro-mechatronics is viewed as giving new birth to another branch of mechatronics, showing precision engineering and system integration. This field introduced the bottoms-up approach from semiconductor technology based on photolithography and the downsizing/miniaturizing approach from conventional mechatronics, emerging into a new field as micromechatronics. Micro sensors are good examples of micromechatronics with the development of microprocessors and micro actuators. The microfabrication method is now still focused, but is gradually going to become part of an integrated control system. Thus, mechatronics is growing more and more with automation technology and society.

There are an increasing number of international journals and meetings in this field. Some of the examples can be seen in [2]–[10].

## Mechatronics in This Transactions

What is mechatronics? This is the main theme of this premiere issue of the new TRANSACTIONS. Many readers may realize how difficult it is to define it clearly. There are numerous definitions by many people. However, none of them can be said to be the best in describing mechatronics, since mechatronics is continually evolving. In this TRANSACTIONS we tentatively define mechatronics as "the synergetic integration of mechanical engineering with electronic and intelligent

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computer control in the design and manufacturing of industrial products and processes." Eleven technical areas included are the following:

1) modeling and design;
2) system integration;
3) actuators and sensors;
4) intelligent control;
5) robotics;
6) manufacturing;
7) motion control;
8) vibration and noise control;
9) micro devices and optoelectronic systems;
10) automotive systems;
11) other applications.

Why mechatronics? As systems become larger and more complicated, we certainly need insight to see the important role of mechatronics by system analysis and integration. It is a practice-based technology unlike any other technology. There are a lot of products in the market which require the modern technology of mechatronics for a higher performance and human friendly interface. As you can see, "robotics" are intelligent machines, which is just one part of the wide fields of mechatronics. Robotics has a market of about $10 billion (U.S.), while mechatronics has a market that is ten times larger.

Thus there are more growing demands for mechatronics such that the technology of mechatronics attracts many people for today's technology as well as tomorrow's. There are various theories regarding mechatronics, but mechatronics is, again, essentially a product-based technology, so we need real working hardware in most cases to convince people. In a sense, mechatronics is viewed as a *postcompetitive* technology. Theory often follows practice. Now we need sound theory and practice in the applications of mechatronics.

How to implement mechatronics? It is important to understand the problem at hand and available mechatronics resources, such as sensing, actuation, and computational capabilities. It is also necessary to analyze the system for better solutions for design and control from the beginning, balancing hardware and software for cost-effectiveness. System design and evaluation are not once-through processes but iterative. Successful prior examples should be referenced with rational thinking, and at the same time new approaches may have to be explored. Good examples will be found in this premiere issue.

## Scanning This Premiere Issue

Since this is the premiere issue of the IEEE/ASME Transactions on Mechatronics, we celebrate the birth of a new publication with contributions by well-known experts in the world.

First, Prof. David Auslander presents his view of mechatronics and defines mechatronics in the form of an essay. He views mechatronics as one of engineering disciplines for complex decision making of both hardware and software systems.

Second, Mr. Nobuhiro Kyura and Mr. Hirosuke Oho, from Yaskawa Electric Company, who are the inventors of the word "Mechatronics" including its development, review the origin of the word "Mechatronics" from its birth in 1969 to the present. Since their interest was in NC machine tools and industrial robots in those days, they explain the brief history of "mechatronics" based on these servo mechanisms, by defining "mechatronics" as a coined term of mechanism and electronics, so that technologies and developed products will incorporate electronics more and more into mechanism, "intimately and organically" and making it impossible to tell where one ends and the other begins.

Prof. Rolf Isermann discusses modeling and design methodology, and describes the process of design and automatic functions, in particular, multilevel information processing, including low level control to a higher level with knowledge bases, inference mechanisms, and intelligent control systems. He also discusses the design of control systems from modeling and identification to adaptive control with several examples. Although this paper is a modified version of a paper which has already appeared in the IEEE Transactions on Industrial Electronics (vol. 43, no. 1, Feb. 1996), we hope this paper will attract the interest of readers in the modeling and design methodology.

Prof. Kamal Youcef-Toumi discusses system integration from both hardware and software points of view, showing examples from high speed robot to the atomic resolution systems. He shows how to obtain the high performance systems by integration of design and control.

Prof. Ren C. Luo discusses sensor technology as one of the key technologies in mechatronic systems. He shows with examples the recent progress of multisensor fusion technology and micro sensors, in particular, proximity displacement sensors, which is a major part of industrial applications including other sensors.

Dr. Martin Buss and Prof. Hideki Hashimoto discuss the directions of research of the intelligent control for human-machine systems. They also explain the utilization of soft computing based on artificial neural networks, fuzzy logic, and genetic algorithm.

Prof. Kouhei Ohnishi and his colleagues discuss the importance of motion control and its robustness in control. They show the disturbance observer and its application in motion control, demonstrating the usefulness of the system.

Dr. Hidenori Ishihara and his colleagues discuss micromechatronics, where micro actuators, in particular, plays an important role in research and development, showing the scaling factor between the micro world and the macro world. They show the *state of the art* and the future of the micromechatronics with recent medical and industrial applications.

Dr. Mark B. Barron and Dr. William F. Powers discuss automotive applications of mechatronics, showing how to make mechatronics cost-effective by continuing research and development. They review electronics in automobiles from audio equipment and power electronics to the near-zero emission and safety system. They still anticipate the impact of semiconductor technologies in automatic mechatronics and the design of robust control algorithms in software.

Finally, we have a paper submitted by Prof. Kiyoshi Ohishi and his colleagues, on the motion control of the ultra-low speed servo system by using the disturbance observer, which is one of the typical problems in mechatronics.

We hope you enjoy reading this new TRANSACTIONS, and that you find it useful and attractive, because of its strong ties with practical applications in industry. Your suggestions and comments on how to make this TRANSACTIONS more valuable for academic, industrial, and governmental sectors are all welcome and would be greatly appreciated for its further improvement.

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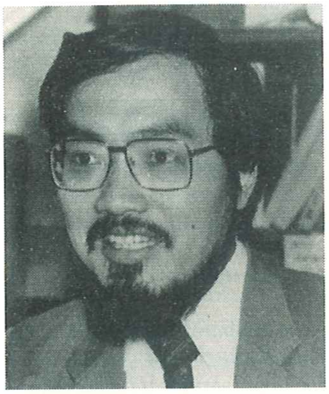

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