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Mechatronics : A Multidisciplinary Field of Engineering

Manzoor Elahi Soudagar
Dept. of Mechanical Engineering, Jain College of Engineering, Belgaum, Karnataka, India

Abstract
Mechatronics refers to mechanical electronic systems and can be described as a theological combination of electronics, electrical, computer control and mechanics which when combined leads to generation of a simple, feasible and reliable systems. Mechatronics integrates sensors, actuators, signal conditioners, power electronics, decision and control algorithms, computer hardware-software to manage complexity in the design and communication in engineered systems. Systems engineering involves design, synthesis of products, analysis and processes involving components from different disciplines. Mechatronics provides a platform for system engineering to guide the product realization process from design, model, simulate, refine, analyze, prototype, validate and deploy the cycle.

Keywords
Mechatronics, Trans-Disciplinary, Information Systems, Control, Simulation.

I. Introduction

The term "Mechatronics" was derived from the two words "mecha" from mechanics and "tronics" from electronics. It was coined by Mr. Tetsuro Mori, a senior engineer of Japanese company Yaskawa in 1969.

A mechatronic system is composed of four basic components. They are sensors, controllers, actuators and mechanical components. Figure 1 shows a schematic diagram of a mechatronic system integrated with the above components.

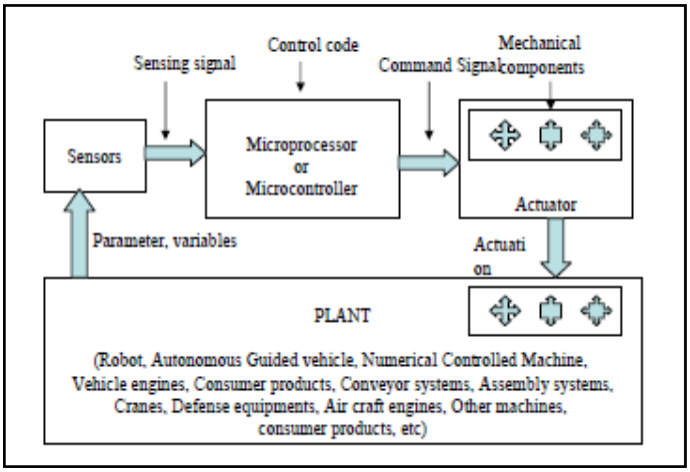

Fig.1: Schematic diagram of Mechatronics system

In the initial design phase, it has to be decided which problems should be solved mechanically and which problems electronically. When different partial designs are worked out, information about these designs can be used for evaluation of the complete system and be exchanged for detailed design of the parts.

In mechatronics system, the mechanical parts have to perform certain motions whereas electronic parts add intelligence to the systems. Power plays a major role in mechanical part and information processing is the main criteria in electronic part. Sensors convert mechanical motions into electrical signals where information content is important. Sensor generates some form of signal, usually an analog signal in the form of a voltage level or waveform. This signal is then sent to an analog to digital converter (ADC). ADC maps the analog input signal to a digital output. The digital value is composed of a set of binary values called as bits. These bits represents a decimal or hexadecimal number that can be used by the microcontroller.

Microcontroller consists of a microprocessor and memory. The program in the microprocessor uses the digital value along with other inputs. Digital to analog converter is used to convert the digital value into an analog signal. The analog signal is used by the actuator to control physical device. The sensor then takes new measurements and the process repeats, thus completing a feedback control loop.

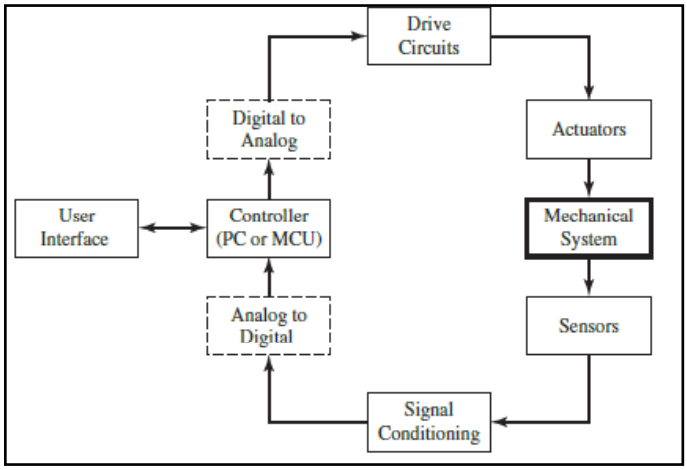

Fig. 2: Typical components of a mechatronics system

Figure 2 shows a typical block diagram of mechatronics system. The system has at its core a mechanical system which needs to be controlled. The controller needs information about the state of the system. This information is obtained from sensors. The signals produced by the sensors need some signal conditioning operations to be performed. These signals are then converted to a digital form and presented to the controller.

The controller processes user commands and senses the signals to generate command signals to be sent to the actuators in the system. The user commands are obtained from various devices such as graphical user interfaces, touch screens or pads.

In some cases, the command signals to the actuators are first converted from digital to an analog form. The actuator converts electrical signals into mechanical motion or action.

II. Disciplinary foundations of mechatronics

Mechatronics is a combination of electrical Engineering, mechanical Engineering, computer Engineering and information systems as shown in Figure 3.

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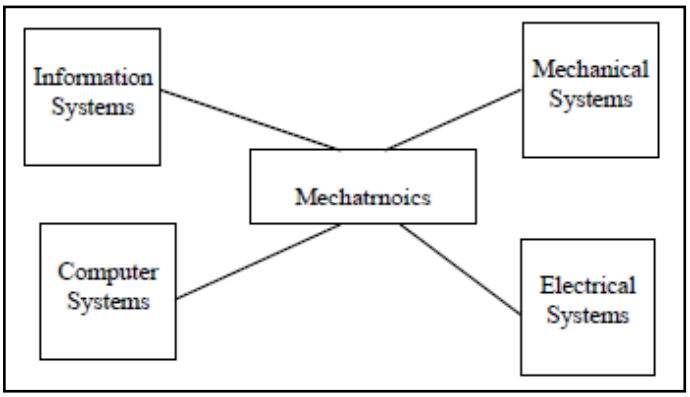

Fig. 3: Disciplinary foundation of Mechatronics

Mechatronics and other trans-disciplinary were introduced in 1970 as multiple integrative possibilities to understand, achieve, transfer and incorporate knowledge in the context of new informational society. There is significant design trend that has a marked influence on the product-development process. While Mechatronics combines mechanics and electronics, it also involves software and information technology, combining new technologies to the existing and combining them to solve problems by integrating different technologies to solve the emerging problems efficiently.

III. Mechatronics Design Process

Figure 4 shows the design process involved in Mechatronics

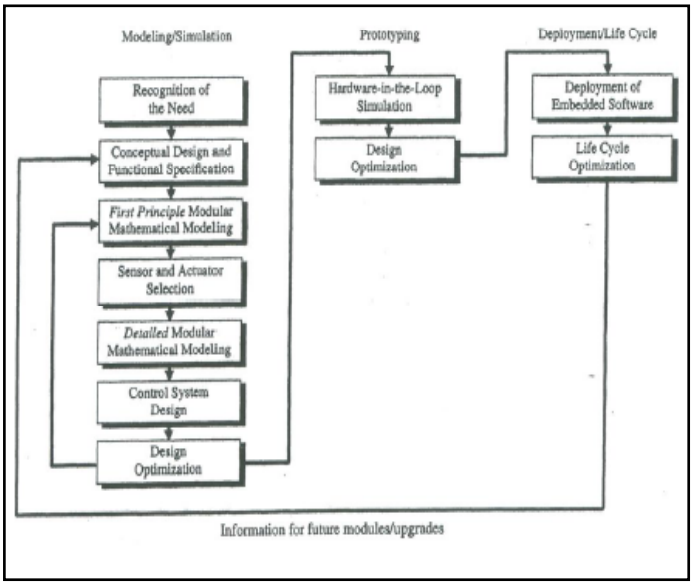

Fig. 4: The Mechatronics design process

The entire design process is divided into hierarchal structured process. It starts with the design of the kinematic, the dynamic and the mechatronic function. Mechatronics embeds in itself control systems to provide a framework for component interactions and the analysis associated with it. Integration within a mechatronic system is performed by a combination of hardware components and software along with information processing. This is known as Hardware-In-The loop simulation process. Hardware integration results from designing the mechatronic system as an overall system which includes actuators, sensors and embedded computers as well.

Software integration depends on control functions and algorithms that need to be performed.

Some of the advantages of the mechatronics design approach are greater productivity, shorter development cycles, faster time to market, higher quality and cheaper products. The results can further be improved by effectively integrating with the concurrent engineering strategies.

Nowadays, a mechanical engineer with training offers three benefits. Firstly, a mechatronics engineer is familiar with the advantages and limitations of trans-disciplinary technologies in both software and electronic hardware. Secondly, a mechatronics engineer has been trained on the application of this knowledge to optimize a mechanical design. Lastly, a mechatronics engineer can understand how to rapidly prototype and test various embedded solutions to implement a final solution.

IV. Examples on Mechatronics systems

Modern society depends on mechatronics-based systems for convenience. Some of the examples of mechatronics systems are as discussed below;

1. Centre lathe : It is used to manufacture cylindrical shapes in various materials. It is mainly mechanical with an electric motor connected to turn the chuck and rotate the work piece. The cutting tools are moved by turning handles or using a drive mechanism.

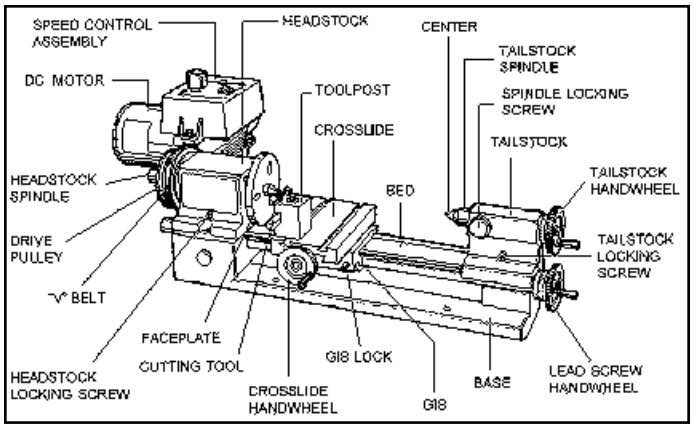

Fig. 5: Parts of Sherlin Lathe showing vertical position of various components.

2. Computer Numerical Control(CNC) and manufacturing cells : CNC generally refers to cutting machines which are combinations of lathes, millers and grinders. They design the machine parts to the required shape and size according to a computer program produced by Computer Aided software(CAD). The work piece and cutting tools are moved by electric or pneumatic actuators that can move them in 3 dimensions(x, y and z). The tools have a microchip embedded in them that carries information about the dimensions. Computer checks them for wear and compensates for it and replaces them with a new one when it is excessive. The programme works for the required x, y and z coordinates and control the movement of the work piece accordingly. Figure 6(a) shows the Computer Numerical Control machine and figure 6(b) shows the software program written in CAD to design certain part of the tool.

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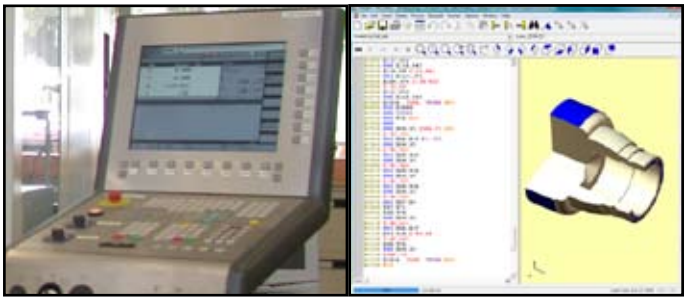

(a) (b)

Fig. 6 : (a) CNC machine (b)Computer Aided Program written for the design certain part of a tool.

CNC machines have different forms and complexity according to the need. Other forms might be machines for cutting shapes with lasers or flame cutters.

Washing machine : A simple twin tub machine consists of a drum driven by an electric motor. It is one of the simplest examples of Mechatronics. Automatic washing machines consist of integrated sensors, controllers and a program to measure the load, fill with water and adjust the temperature. Various programs are written to execute the steps such as to agitate, wash, rinse and spin. The system uses solenoid valves to fill and drain the drum. Depending on the program, these are all processed to activate the power control and speed of the motor.

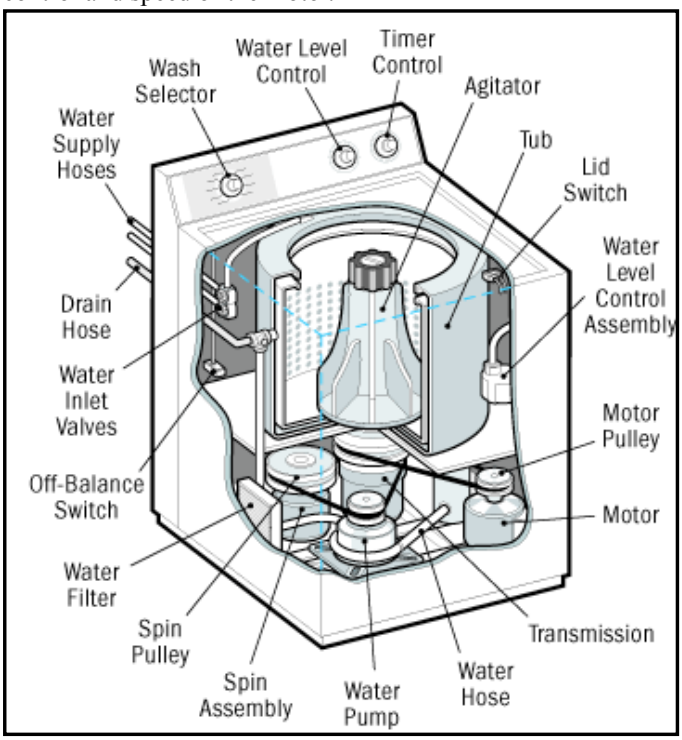

Fig. 7: Inside view of an automated washing machine

V. Mechatronics vs. Multidisciplinary

The difference between a mechatronics system and a multidisciplinary system is not the constituents, but the order in which they are designed.

Multidisciplinary system design employs a sequential design-by-discipline approach whereas mechatronics design methodology is based on a concurrent approach to discipline design, resulting in products with more synergy.

VI. Conclusion

Mechatronics represents a unique combination of interdisciplinary and intelligent engineering science that features an interdisciplinary knowledge. Mechatronics is a fusion of mechanics, electrical, electronics, informatics and intelligent systems. Interdisciplinary Mechatronics concerns mastering a multitude of disciplines and technologies whereas the science of mechatronics concerns the invention and development of new theories, concepts and tools in response to new needs evolving from interacting scientific disciplines. Mechatronics is a study which focuses on producing engineers who can work inn high-technology environment and emphasize on real-world hands-on experience and engage in challenging problems and complex tasks with innovation and enthusiasm.

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Author's Profile

Mr. Manzoor Elahi Soudagar is an Assistant Professor at the Department of Mechanical Engineering at Jain College of Engineering, Belgaum. He completed Bachelor of Engineering in Mechanical Engineering at S. D. M College of Engineering and Technology, Dharwad. He pursued his Master's in Engineering Analysis and Design at S. D. M College of Engineering and Technology, Dharwad. His area of interests include Manufacturing technology, FEA, Computer Aided Drawing and applications. He has an experience of 2+ years in teaching and training Mechanical Engineering Stream.

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