Mechatronics: The Synergistic Integration of Mechanical Engineering with Electronics and Control Engineering

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***Abstract*—**Mechatronics, the word itself signifies that it is a combination of "Mechanical" and "Electronics". It comprises of computer technology, mechanical, electronics, electrical & control engineering. It is an Integration of all technologies together that forms a major part in the design, manufacture and maintenance of wide range engineering products and designs. In industries there is no limit of scope of Mechatronics. This article focuses on the synergistic integration of systems.

Keywords- *Mechatronics, Integrated approach, Key elements*

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I. INTRODUCTION

The term "Mechatronics" was first assigned by Mr. Tetsuro Mori, a senior engineer of the Japanese company Yaskawa, in 1969, which indicates that it is a combination of Mechanical & Electronics that control mechanical systems.

It is a fast developing interdisciplinary field of engineering. New products and systems based on the integrated application of mechanical, electronic and computing engineering technologies are demonstrating reduced mechanical complexity, increased performance and often previously impossible capabilities. These advantages have been stimulated by factors including developments in microprocessors, new improved sensors and actuators, advances in design and analysis methods, simulation tools and software techniques.

For Mechatronics, French standard NFE 01-010 is used. As per this standard Mechatronics is defined as" approaching aiming at the synergistic integration of mechanics, science within the product designing & manufacturing, in an order to improve and/or optimize its functionality."

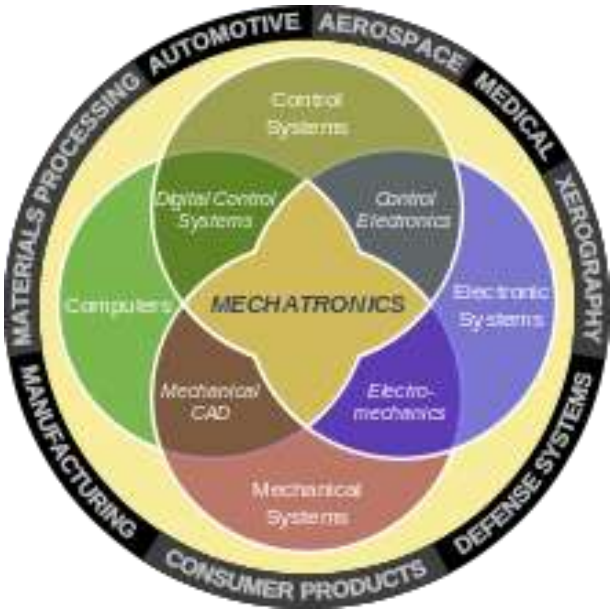
Here "Synergy" means, when two or more systems work together, they are successful than they work separately.

Mechatronics is defined in many ways, some are as stated below:

"Integration of electronics, control engineering, and mechanical engineering."

"Synergistic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacturing of industrial products and processes."

"It is defined as integration of mechanical engineering, electronics and computer technology is increasingly forming a major part in design, manufacture and maintenance of wide range of engineering products and design."



[4]Fig. Mechatronics Systems

II. KEY LEMENTS OF MECHATRONICS

The key elements of Mechatronics system can be classified under following categories:

1. Information system
2. Mechanical System
3. Electrical System
4. Computers
5. Sensors & Actuators
6. Real time interfacing

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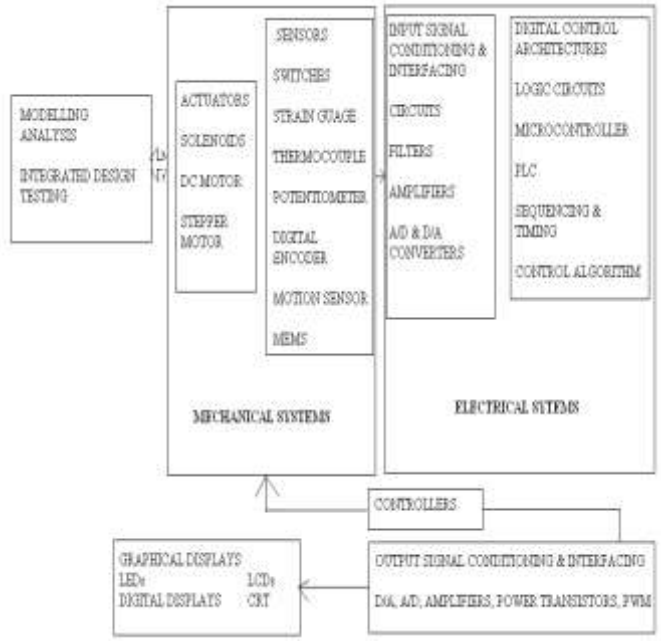
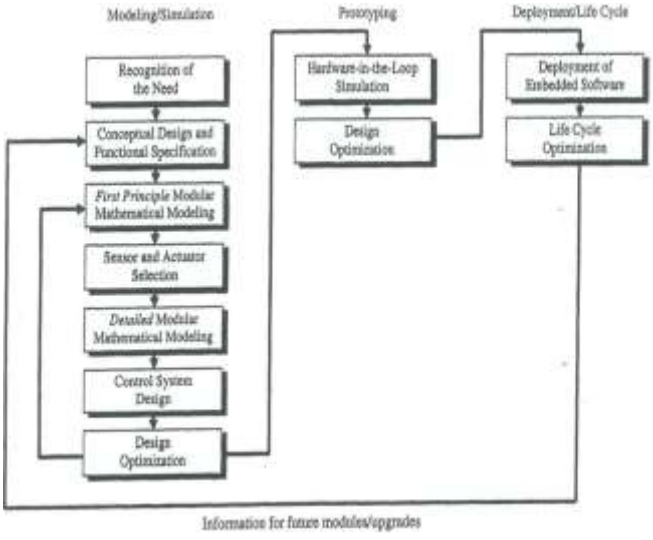


[1] Fig. Key elements in Mechatronics systems

The actuators and sensors form a mechanical system. The actuator produces motion or causes some action whereas sensors detect the state of the system parameter, inputs and outputs. The input signal conditioning and interfacing system provide connection between the control circuits and input/ output system. The overall control of the system is carried out by digital controls. The graphical display of devices provides visual feedback to the users.

III. INTEGRATED DESIGN APPROACH



[5] Fig. Phases of Mechatronics design process

Selecting a Template (Heading 2)

A Mechatronics system consists of many types of interconnected subsystems and components. A traditional approach is to design the electrical and mechanical system separately and interconnect these systems together. The traditional systems however results in many problems such as: the original characteristics and operating conditions of the two will change due to actual loading; perfect impedance matching of the two independently designed systems will be almost impossible. Therefore an integrated approach is designed which supports the concept of concurrent engineering.

Mechatronics exploits systems engineering to guide the product realization process from design, model, simulate, analyze, refine, prototype, validate, and deployment cycle.

[1] Mechatronics design process essentially consists of three aspects:

1. Modelling & design

Here physical systems are represented by a suitable model for describing the behavior characteristics such as block diagrams. Numerical or computer simulation methods are used for solving models.

Modeling and design can be done by understanding the system & its intended function and objectives. The models can be analyzed with computer simulations for obtaining useful information which guide the design process.

2. Prototyping

It is the process of replacing non computer sub-systems with the actual hardware. Sensors and actuators are interfaced with the input and output signals and connected with the models, resulting in partial mathematical and real models. Mathematical part provides simulated time based response. Real part provides real time analysis. These two combines together to understand and validate the design.

3. Deployment

This is associated with the final product, embedded software deployment and lifecycle.

IV. LEVELS OF MECHATRONICS SYSTEMS[2]

Modern Mechatronics systems can be categorized in the following broad categories:

A. *Stand Alone Systems: Examples- Washing machine, Compact disk player, Auto focus Camera, Boat auto pilot, etc.*

B. *Systems with high level of Distributed Sensor: Microcontroller- actuator relationships, Ex- Wire Craft.*

C. *A Large Factory System: This is a distributed system but which links a number of major subsystems such as machining centers, robots for part handling, etc.*

D. *A system that incorporates Intelligent Control (Artificial Intelligence): Ex- Humanoid Robot.*

V. REAL TIME MECHATRONICS SYSTEMS

A system is said to be real time system if there is total correctness of an operation. This depends on operation's logical correctness and the time in which it is performed and used. There are two types of real time systems:

1. Hard Real Time Systems

In this systems, the completion of an operation after its deadline is considered useless.

2. Soft Real Time Systems

It tolerates lateness and may respond with decreased service quality.

VI. MECHATRONICS APPLICATIONS

• Smart consumer products: home security, camera, microwave oven, toaster, dish washer, laundry washer-dryer, climate control units, etc.

• Medical: implant-devices, assisted surgery, etc.

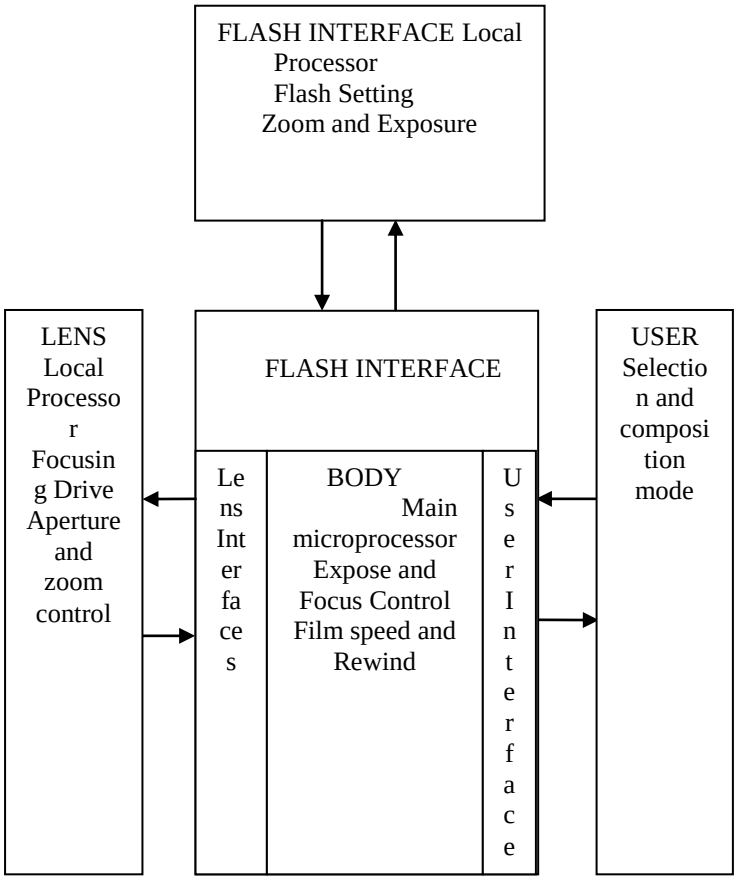
• Defense: unmanned air, ground, and underwater vehicles, smart munitions, jet engines, etc.

• Manufacturing: robotics, machines, processes, etc.

• Automotive: climate control, antilock brake, active suspension, cruise control, air bags, engine management, safety, etc.

• Network-centric, distributed systems: distributed robotics, telerobotics, intelligent highways, etc.

[1] AUTOMATIC CAMERA



In modern camera, additional features like focusing and exposure facilities are available. The basic elements of the control system used in an automatic camera are body, lens and flash. Depending upon the mode selected the required combination of aperture and shutter speed and focus are automatically taken care of by the camera. A camera system comprises of drives, sensors, interfaces for lenses, flash and user. Drives are used in film advance, rewind, shutter movement, focus, zoom, etc. The sensors are used for sensing film speed, focus, zoom, exposure, counters, etc. Microprocessors are used for controlling various operations like systems for lenses, user and flash. The user feeds the information for achieving the desired composition. When the switch is ON, it activates the system and the object is photographed. The microprocessor takes the input from the sensor and sends the respective output to the lens. The lens position is fed back to the microprocessor and it modifies the same. When the photographer selects the shutter controller, the shutter opens up for the photograph and the photograph is taken, the microprocessor gives an output to the motor drive to advance the film for the next photograph.

VII. CONCLUSION

Mechatronics is the systematic approach for integration of mechanical, electrical, electronic engineering. It involves various trends like control systems, sensors, computers, etc. hence is the heart of automation.

VIII. REFERENCES

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