Mechatronics — An Introduction to Mechatronics

N. Pannaga
M. Tech scholar,
Department of Mechanical,
Visvesvaraya Technological University,

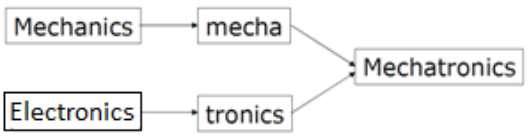
N. Ganesh
M. Tech scholar,
Department of Aerospace Propulsion Technology,
Visvesvaraya Technological University,

Ravish Gupta
M. Tech scholar,
Department of Electronics & communications,
Rajiv Gandhi Proudyogiki Vishwavidyalaya,

Abstract

Innovation in today's Industrial system or industrial control system (ICS) is often only possible due to the embedded system. Particularly, the software connects previously isolated systems resulting in, so-called, advanced mechatronic systems. Mechatronics is an interdisciplinary way of combining the classical engineering disciplines for mechanical and electrical engineering, electronic engineering and computer science. The word, Mechatronics is composed of mechafrom mechanics and tronicsfrom electronics. In other words, technologies and developed products will be incorporating electronics more and more into mechanisms, intimately and organically, and making it impossible to tell where one ends and the other begins.

Field of study involving the analysis, design, synthesis, and selection of systemsthat combine electronics and mechanical components with modern controls andmicroprocessors



Keywords

Mechatronics system, Mechatronics Definitions, Mechatronics Design Step, Objectives of Mechatronics.

1. INTRODUCTION

The word Mechatronics was first introduced by the senior engineer of a Japanese company, Yaskawa, in 1969. The company was granted trademark rights on the word in 1971. The word soon received broad acceptance in industry and, in order to allow its free use, Yaskawa decided to abandon his rights on the word in 1982. The Mechatronics systems consist of components from different physical domains, which are closely coupled and therefore interact with one another. Moreover, the behavior of the components is highly non-linear.

2. WHAT IS MECHATRONICS?

Today it means mechatronics engineering activities including designing, testing and operation of machinery and equipment, in which there is a high level of functional integration of mechanical systems with electronics and computer control.

Mechatronics is an interdisciplinary field, combining in a synergistic manner the classical knowledge of mechanical engineering, hydraulics, pneumatics, electronics, optics and computer science. A typical mechatronic system picks up signals from the environment, processes them to generate output signals, transforming them for example into forces, motions and actions. The aim of Mechatronics is to improve the functionality of technical systems and the creation of new concepts of machinery and equipment with built-in "artificial intelligence".

Mechatronics provides an opportunity, not only humanization of machines, but also it changes the mindset and the approach to technological issues and most importantly teaching new technologies and ways of acquiring knowledge and skills. The most important feature of mechatronic devices is the ability to process and communicate information accurately in a form of different types of signals (mechanical, electrical, hydraulic, pneumatic, optical, chemical, biological), with high level of automation of these devices.

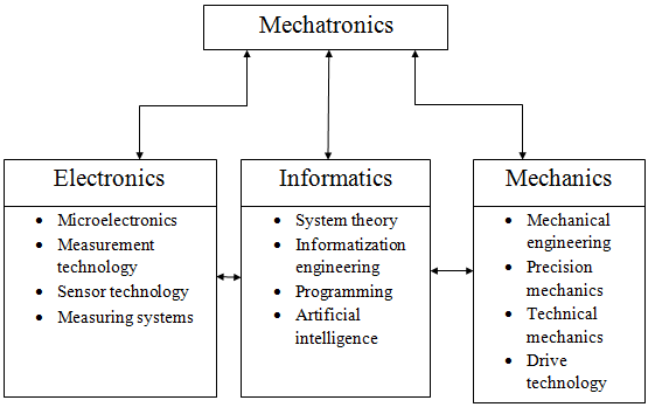


Figure: - Mechatronics System

Nowadays a lot of machines and even simple household appliance consist of mechanisms driven by motors and actuators with electrical control circuits. The overall control of these machines is done by programmable components like PLC's, micro-controllers or even PC's. The major difference between conventional machinery with electronic components and mechatronic machinery is that the former adds electronic components, while the latter integrates electronic components. Adding some electronics to a machine means adding additional functions, and integrating electronics means furnishing extended capability to the machinery.

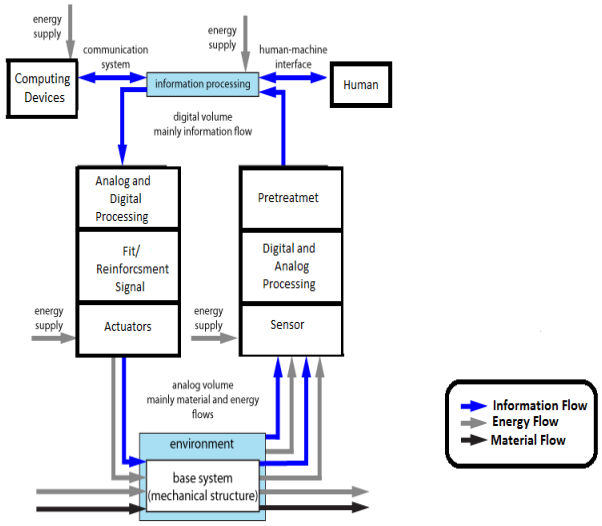
3. Mechatronics Definitions

Mechatronics is the synergistic integration of sensors, actuators, signal conditioning, power electronics, decision and control algorithms, and computer hardware and software to manage complexity, uncertainty, and communication in engineered systems.IEEE (Institute of Electrical and Electronics Engineers) and ASME (American Society Mechanical Engineers) promote the following definition: “Mechatronics is the synergistic integration of mechanical engineering with the electronic control and the intelligent, PC-based control, in the design and manufacturing of goods and processes.”

4. Objectives Of Mechatronics

Mechatronics has mainly the objective to improve technicalproperties, i.e., to make machines work faster and to make manufacturing cheaper. In industry, products and processes are designed fromscratch, and therefore they are known, and dealing with them is a kind of straightforward actionwhere the behavior can be predicted, at least in principle. Even there, however, the complexity oftasks and situations is increasing, leading already

to the use of unconventional tools like fuzzy control,neural networks, expert systems, and their combinations. Figure shown the mechatronics industry system



5. Mechatronics Design Step

Mechatronic products are commonly used in industry and everyday life. Designing of mechatronic products requires aedicated approach that takes into account: interdisciplinary design, market related constraints, multifunctionality, user-friendly operation and demand of minimization of the cost of the whole product operation period. Thus designers who create mechatronic products should possess comprehensive interdisciplinary knowledge, ability to co-operate in an interdisciplinary designing team as well as team management skills, and knowledge how to use the up-to-date tools of computer aided engineering. Additionally the know-how in scheduling and carrying out prototyping of mechatronic systems is very useful.

6. Type of Elements

Electromechanical elements: -

Sensors, A variety of physical variables can be measured using sensors. Actuators, DC servomotor, stepper motor, relay, solenoid, speaker, light emitting diode (LED), shape memory alloy, electromagnet, and pump apply commanded action on thephysical process.IC-based sensors and actuatorsdigital-compass, potentiometer, etc.

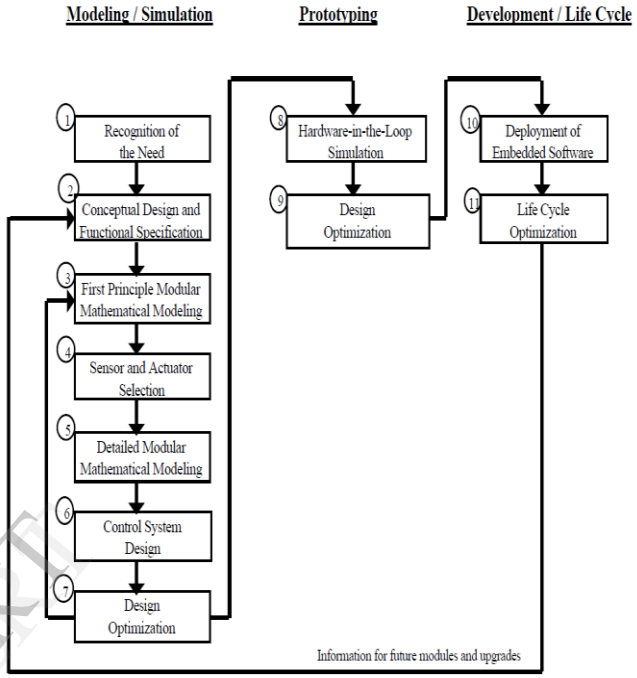


Fig: - Mechatronics Design Process

Electrical elements:-

Electrical components e.g., resistor (R), capacitor (C), inductor (L), transformer, etc

Electronic elements:-

Analog/digital electronics, transistors, thyristors, opto-isolators, operationalamplifiers, power electronics, and signal conditioning.

Control interface /computing hardware elements:-

Analog-to-digital (A2D) converter, digital-to-analog (D2A) converter, digitalinput/output (I/O), counters, timers,

microprocessor, microcontroller, dataacquisition and control (DAC) board, and digital signal processing (DSP) board

Computer/Information System:-

Computer elements refer to hardware/software utilized to perform, computer-aided dynamic system analysis, optimization, design, and simulation, virtual instrumentation, rapid control prototyping, hardware-in-the-loop simulation, PC-based data acquisition and control

Elements of Mechatronics:-

Typical knowledgebase for optimal design and operation of mechatronic systems comprises of: – Dynamic system modelling and analysis. Thermo-fluid, structural, hydraulic, electrical, chemical, biological, etc.– Decision and control theory, Sensors and signal conditioning, Actuators and power electronics, Data acquisition. A2D, D2A, digital I/O, counters, timers, etc.– Hardware interfacing, Rapid control prototyping, Embedded computing.Balance theory, simulation, hardware, and software.

Mechatronics is the result of applying information systems to physicalsystems. The physical system, the rightmost dotted block, consists of mechanical, electrical, andcomputer (electronic) systems as well as actuators, sensors, and real time interfacing. Sensorsand actuators are used to transduce energy from high power, usually the mechanical side, to lowpower, the electrical and computer or electronic side. The block labeled mechanical systemsfrequently consists of more than just mechanical components and may include fluid, pneumatic,thermal, acoustic, chemical, and other disciplines as well.

7. New Research Challenges

These interactively cooperating, intelligent machines lead to new research topics in the controltechniques of mechatronics and in other areas as well. It will be important that a machine and itscomponents have learning capabilities, self-adaptation and self-calibration. Techniques such as thecombination of neural networks, and fuzzy control with expert systems will further emphasize theimportance of software.

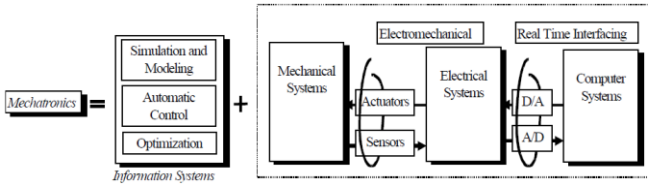


Fig: - Elements of Mechatronics

Mechatronic Engineering is the engineering discipline concerned with the research, design, implementation and maintenance of intelligent engineered products and processes enabled by the integration of mechanical, electronic, computer, and software engineering technologiesSpecific expertise areas can include:

- Artificial Intelligence Techniques
- Avionics Computer Hardware and Systems Control Systems
- Data Communications and Networks
- Dynamics of Machines and Mechanisms
- Electromagnetic Energy Conversion
- Electronics
- Embedded & Real-time Systems
- Fluid Power and other Actuation Devices
- Human-Machine Interface Engineering and Ergonomics
- Industrial Automation
- Measurement, Instrumentation and Sensors
- Mechanical Design and Material Selection

- Mechatronic Design and System Integration
- Modelling and Simulation
- Motion Control
- Power Electronics
- Process Management, Scheduling, Optimization, and Control
- Process Plant and Manufacturing Systems
- Robotics
- Signal Processing
- Smart Infrastructure
- Software Engineering
- Systems Engineering
- Thermofluids
- Haptic Interfaces
- Medicals
- Automation
- Robotics
- Control
- Mechanical Vibrations

8. Mechatronics In Medicine

In 1985 the Department of Mechanical Engineering at Imperial College began research into medical robotics for neurosurgery. Further research into a robot for prostatectomy, commencing in 1988 culminated, in 1991, in a "World First" with the demonstration of robotic prostate surgery. This robot was the first to actively remove tissue from a human patient in an operating theatre. With the expansion of robotic surgery applications, the Mechatronics in Medicine Laboratory was set up in 1993, as part of the Computer Aided Systems Engineering Section, to research and develop mechatronic aids to surgery. The group has developed mechatronic applications in fields as diverse as neurosurgery, magnetic resonance imaging (MRI) compatible robotics, haptic training systems for surgeons, urological surgery and orthopaedics, high intensity focused ultrasound and blood sampling.

9. New Applications

i-VTEC, Micro Air Vehicles, Pistonless Pump, Multi Air Engine, Six Stroke Engine, Solar Cars, Thermo Acoustic Refrigeration, Biodeisel, Digital Twin Spark Ignition, Nano Enabled Coating Makes Aircraft Invisible, Automatic Transmission In Cars, Nitro Shock Absorbers, Hypercar, 3d Machine Vision Systems, Geothermal Energy, Cryogenic Heat Treatment, Next Generation 2-Stroke Engine, Microturbines, Next Generation Engines, Tidal Energy, Air Craft Hydraulic System, Cruise Missile Technology, Camless Engine, Automatic Vehicle Locator, Autonomous Car, Solar Energy Through Solar Space Stations, Anti-Lock Braking Sensors, Air Muscles, SkyBus Technology, Scramjet Engine, Pollution Less Engine, Paper Battery, Nano IC Engine, Liquid Nitrogen, Gasoline Direct Injection, Emulsified Ethanol, Direct Injection Diesel Engine, Vehicle Dynamics, Valvetronics, Tidal Power, Hovercraft, Infrared Curing and Convection Curing, Aeroplane Propulsion System, Running gearing, Fuel Energizer, GPS And Applications, Selective Laser Sintering, Agile Manufacturing, Cryocar, Cylinder deactivation, Dyna-cam engine, Apache Helicopter, CAMM Systems, Friction Stir Welding, HEMI engines, Just In Time Manufacturing, Lean manufacturing, Quality improvement tool "poka yoke", MEMS for Space, Personal Protection ,, Mine Detection Using Radar Bullets, Overall Equipment Effectiveness, Predictive Maintenance using Thermal Imaging, Methanol Fueled Marine Diesel Engine, Quality function deployment, Quasi turbine, Robots In Radioactive Environments, Sidewinder Missile, Smart Materials, Transit

Mixer & Concrete Pump, Turbofan Engine, Solar Sails, Ultrasonic Metal Welding, The Hy-Wire Car, Thermal Barrier Coatings, Ultrasonic Techniques for hidden corrosion detection, Solar-powered vehicles , Two Stroke Engine Using Reed Valves, Vacuum Braking System, Variable Valve Timing In I.C. Engines, Space Elevator, Supercavitation, Thermal shock on interfacial adhesion of thermally conditioned, Total Productive Maintenance, Welding Robots , Air powered cars, Biomechatronic Hand , Computer Aided Process Planning , Re-entry of Space Vehicle, Sensotronic Brake Control, Skid Steer Loader and Multiterrain Loader, Space Robotics, Space Shuttles and its Advancements, Continuously variable transmission (CVT), Cryogenic grinding, Design, Analysis, Fabrication And Testing Of A Composite Leaf Spring, F1 Track Design and Safety, Green Engine, Head And Neck Support (HANS), Hydro Drive , Fractal Robots, Smart Bombs,, Military Radars, Stealth Fighter, Handfree Driving, Solar Power Satellites (SPS), Nano Technology, Iontophoresis, Aerodynamics, Micro-Electromechanical Systems.

10. References

1. Nadine Le Fort-Piat, Alain Bourjault - Recent Trends in Mechatronics ISTE Publishing Company | 2003 | ISBN: 1903996465 | Pages: 128
2. D. G. Alciatore and M. B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw Hill, 1998.
3. T. Mori, “Mechatronics,” Yasakawa Internal Trademark Application Memo, 21.131.01, July 12, 1969.
4. Advanced Mechatronics: Monitoring and Control of Spatially Distributed SystemsWorld Scientific Publishing Company | ISBN: 9812771816 | 2008-11-06
5. NikolayAvgoustinov, "Modelling in Mechanical Engineering and Mechatronics: Towards Autonomous Intelligent Software Models" Springer | 2007 | ISBN: 1846289084 | 226 pages
6. Masaharu Takano, Tatsuo Arai, Eiji Arai, "Human Friendly Mechatronics"Publisher: Elsevier | ISBN: 0444506497 | 2001 |
7. Godfrey Onwubolu, “Mechatronics: Principles and Applications"Butterworth-Heinemann | 2005-06-28 | ISBN:0750663790
8. Mechatronic Systems: Devices, Design, Control, Operation and Monitoring Publisher: CRC | Pages: 496 | 2007-10-17 | ISBN 0849307759 |
9. de Silva W., "Mechatronics : An Integrated Approach" Publisher: CRC Press Inc | ISBN: 0203502787 | 2004
10. Essentials of Mechatronics 280 pages | Wiley-Interscience (June 5, 2006) | ISBN-10: 047172341X
11. Hyungsuck Cho "Optomechatronics: Fusion of Optical and Mechatronic Engineering (Mechanical Engineering)" CRC | 2005-11-29 | ISBN: 0849319692
12. Edwin Kiel, E. Kiel “Drive Solutions: Mechatronics for Production and Logistics" Springer | 2008-01-28 | ISBN: 3540767045
13. Andrzej M. Pawlak “Sensors and Actuators in Mechatronics: Design and Applications" CRC | 2006-07-28 | ISBN: 0849390133
14. ClarenceW. de Silva " Mechatronic Systems: Devices, Design, Control, Operation and Monitoring Series) " CRC (October 17, 2007) | ISBN: 0849307759
15. by M. Nakamura , S. Goto , N. Kyura , T. Zhang , Masatoshi Nakamura , Satoru Goto , NobuhiroKyura " Mechatronic Servo System Control " Springer ; 1 edition | 2004 | English | ISBN: 3540210962

16. John Billingsley , Robin Bradbeer " Mechatronics and Machine Vision in Practice " Springer; 1 edition (December 20, 2007) | ISBN: 3540740260
17. Robert H. Bishop " Mechatronic Systems, Sensors, and Actuators: Fundamentals and Modeling " CRC (November 19, 2007) | ISBN: 0849392586
18. Robert H. Bishop " Mechatronic System Control, Logic, and Data Acquisition (The Mechatronics Handbook, Second Edition) " CRC (November 19, 2007) | ISBN: 0849392608
19. RyszardJablonski, Mateusz Turkowski, Roman Szewczyk, "Recent Advances in Mechatronics" Springer; 1 edition (October 12, 2007) | ISBN:3540739556
20. A. Preumont "Mechatronics: Dynamics of Electromechanical and Piezoelectric Systems"ISBN: 1402046952 | Publisher: Springer (September 25, 2006) | 2006-09-25 |