Mechatronic Systems Design

MEC301

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Lecture 1: **Mechatronic Systems: Overview**

The Lecturer

About Me

Mohammed Nour *Abdelgwad* **Ahmed**

- **Asst.Prof.Dr.Ing.** at Computer and Systems Engineering Dept., Faculty of Engineering, Zagazig University.
- **Researcher** at DFKI–Robotic Innovation Center, Bremen, Germany.
- Research Interests: Robotics, Control, Modelling and Simulation, and Mechatronics

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- Office **Hours**: each Sunday and Tuesday after 14:00 o'clock

The Lecturer

Some robots I worked with

SpaceClimber

CREX

The Lecturer

Some robots I worked with

LIMES (Mantis)

EOscc2

The Lecturer

Some robots I worked with

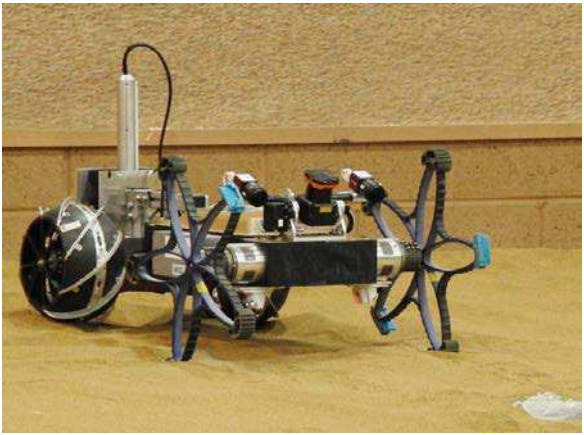
AILA

Mr.SemProm

The Lecturer

Some robots I worked with

MIRA



Coyote2

The Course

MEC301: Mechatronic Systems Design

Assessment Methods

Method	Time	Weight
Assignments, Quizzes, $\cdots$	weekly	15
Midterm	week 6	25
Project (Project Report + Demo)	week 10	10
Final	week 12	50

Recommended Textbooks

- Klaus Janschek, **Mechatronic Systems Design: Methods, Models, Concepts**, ISBN: 978-3-642-17530-5 (Print) 978-3-642-17531-2 (Online),Springer Berlin Heidelberg, 2012
- R C Dorf & R H Bishop, **Modern Control Systems**, Pearson Prentice Hall, 2008.

Relevant Websites

- Lecture slides, notes and others on course webpage: https://mnourgwad.github.io/MEC301

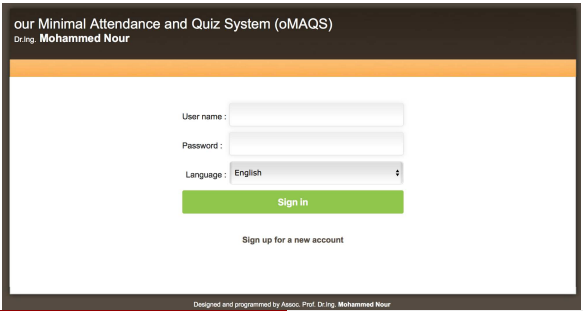
Sign up to the System

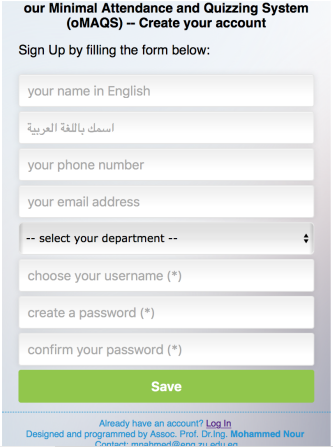
In your **smart** phone:

1. connect to WiFi network **Nour**
2. password: **12345678**

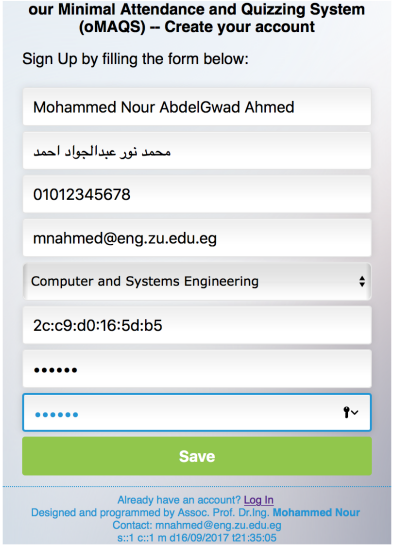
in phone Internet browser:

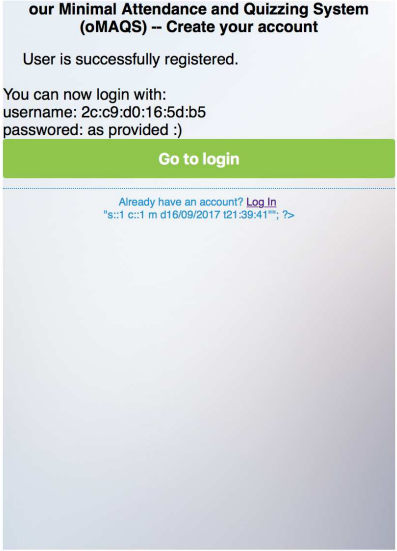
1. navigate to the address: **192.168.1.2**





Sign up to the System





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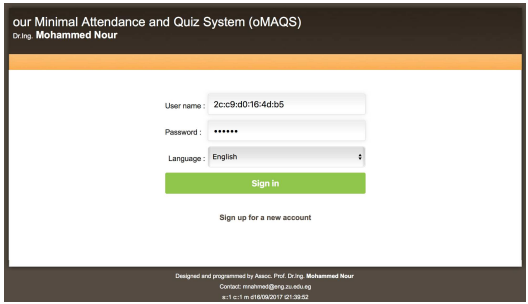
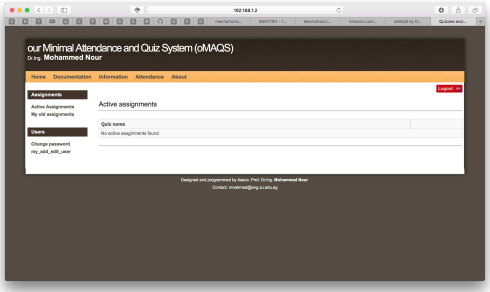




Mechatronics Definition

- The word, mechatronics, is composed of **mecha** from mechanism and the **tronics** from electronics.

Mechatronics

- the application of complex decision making to the operation of physical systems.
- a methodology used for the optimal design of electromechanical products.

A mechatronic system is not just a mix of electrical and mechanical systems and is more than just a control system; it is a complete integration of all of them.

Mechatronics Definition

Mechatronics

describes an interdisciplinary **design methodology** which solves primarily mechanically oriented product functions through the synergistic spatial and functional **integration** of mechanical, electronic, and information processing subsystems.[a]

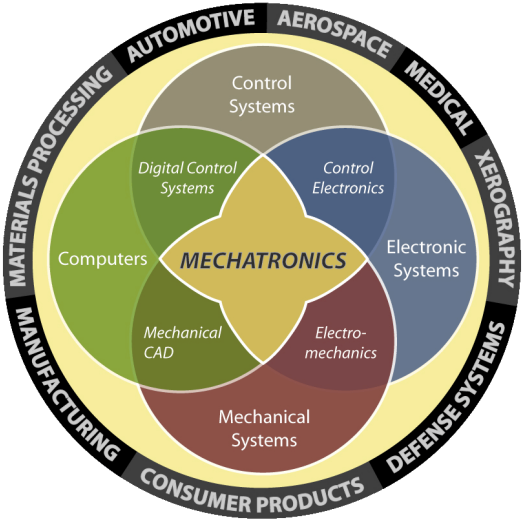
[a] **VDI/VDE** Gesellschaft für Mess- und Automatisierungstechnik (GMA)–Society for Measurement and Automatic Control (VDI/VDE GMA), Technical Committee 4.15 “Mechatronics”

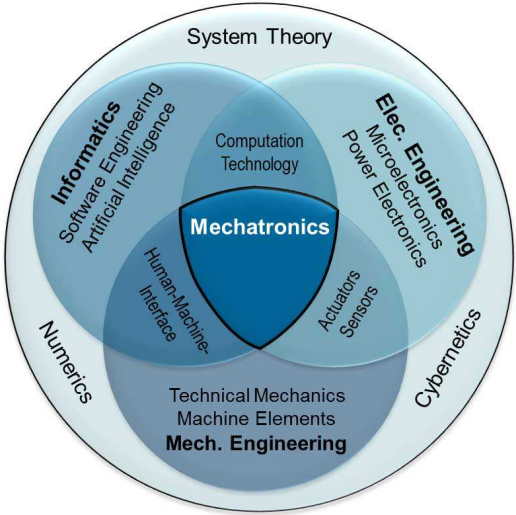
Mechatronics

the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes. It covers the **integrated design** of mechanical parts with an **embedded** control system and information processing.[a]

[a] International Federation of Automatic Control (**IFAC**)–Technical Committee on Mechatronic Systems

Mechatronic Systems





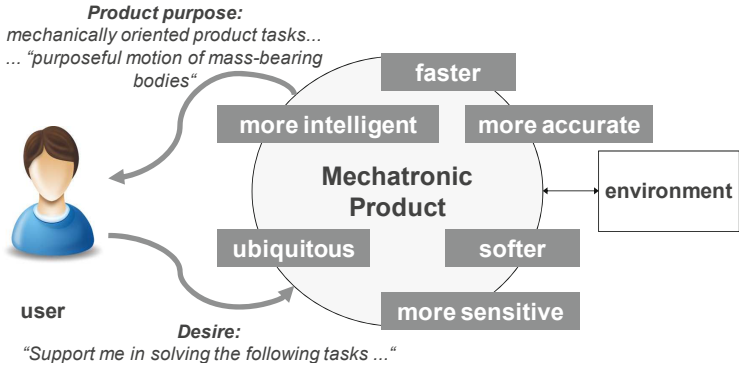
https://en.wikipedia.org/wiki/Mechatronics

Product-Oriented Perspective

Mechatronics Engineering is the:

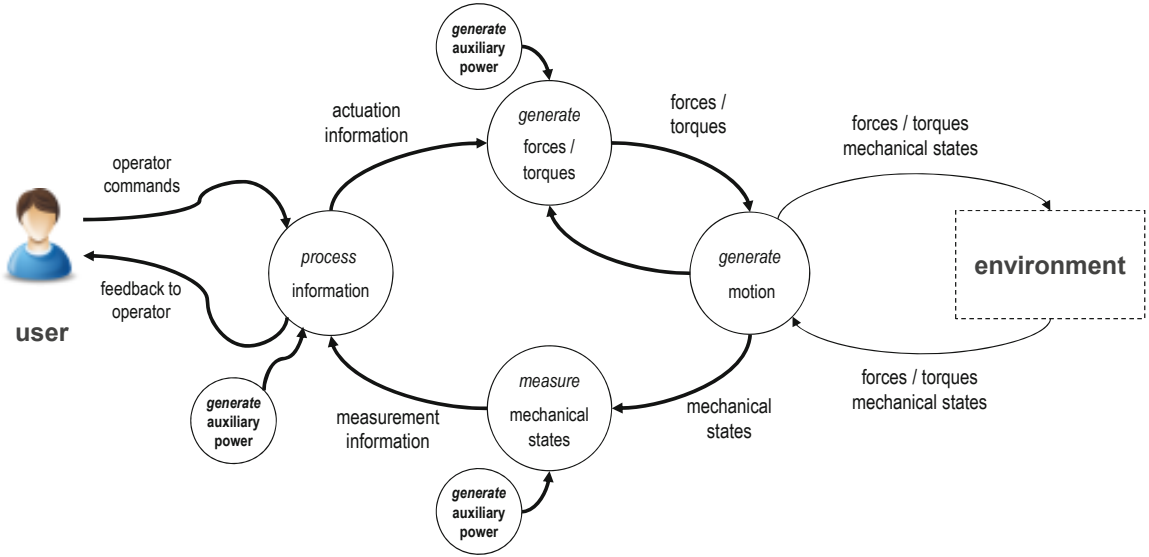
- Analysis,
- Design,
- Manufacturing,
- **Integration**, and
- maintenance

of mechanics with electronics through intelligent computer control.

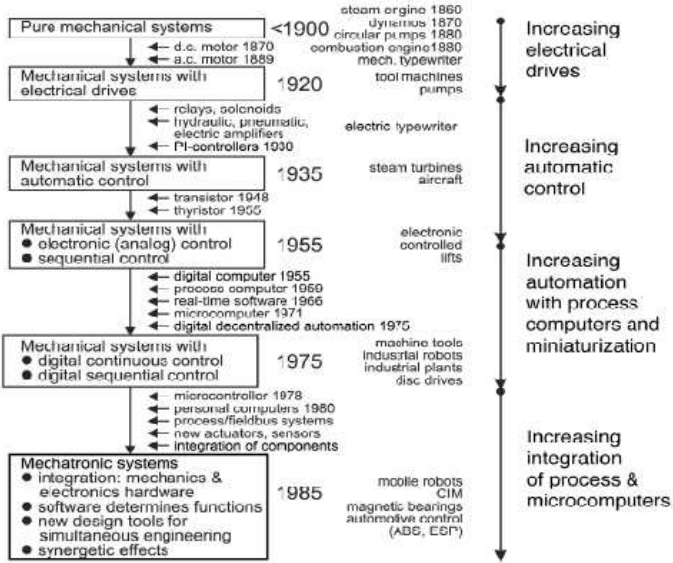


Mechatronic systems as products with exceptional attributes: external perspective

Function–Based Structure



History


Pure mechanical systems
<1900
steam engine 1860
dynamos 1870
circular pumps 1880
combustion engine1880
mech. typewriter
d.c. motor 1870
a.c. motor 1889
Mechanical systems with electrical drives
1920
tool machines
pumps
relays, solenoids
hydraulic, pneumatic, electric amplifiers
PI-controllers 1930
electric typewriter
Mechanical systems with automatic control
1935
steam turbines
aircraft
transistor 1948
thyristor 1955
Mechanical systems with
electronic (analog) control
sequential control
1955
electronic controlled lifts
digital computer 1955
process computer 1960
real-time software 1966
microcomputer 1971
digital decentralized automation 1975
Mechanical systems with
digital continuous control
digital sequential control
1975
machine tools
industrial robots
industrial plants
disc drives
microcontroller 1978
personal computers 1980
process/fieldbus systems
new actuators, sensors
integration of components
Mechatronic systems
integration: mechanics & electronics hardware
software determines functions
new design tools for simultaneous engineering
synergetic effects
1985
mobile robots
CIM
magnetic bearings
automotive control (ABS, ESP)
Increasing electrical drives
Increasing automatic control
Increasing automation with process computers and miniaturization
Increasing integration of process & microcomputers

Historical Development

- Mechanical Engineering experienced an exponential growth in the early **19th century** because of the **industrial revolution**.
- The rise of **semiconductors** in the **1950s** and computers in the 1980s have revolutionized all engineering products and processes which in turn affected mechanical engineering systems.
- The **term mechatronics** was first used in the late **1960s** by a Japanese Electric Company to describe the engineering integration between mechanical and electronics systems.
- Mechatronics system engineering has gained much recognition and importance in industry
- Today, many mechanical systems use some form of electronics and computers to control its functionality.

History

In the late **1970s**, the Japan Society for the Promotion of Machine Industry (JSPMI) **classified mechatronics products into four categories**

Class I:

- **Primarily mechanical** products with electronics incorporated to enhance functionality. Examples: NC machine tools and variable speed drives in manufacturing machines.

Class II:

- **Traditional mechanical** systems with significantly **updated** internal devices incorporating electronics. Examples: modern sewing machine and automated manufacturing systems.

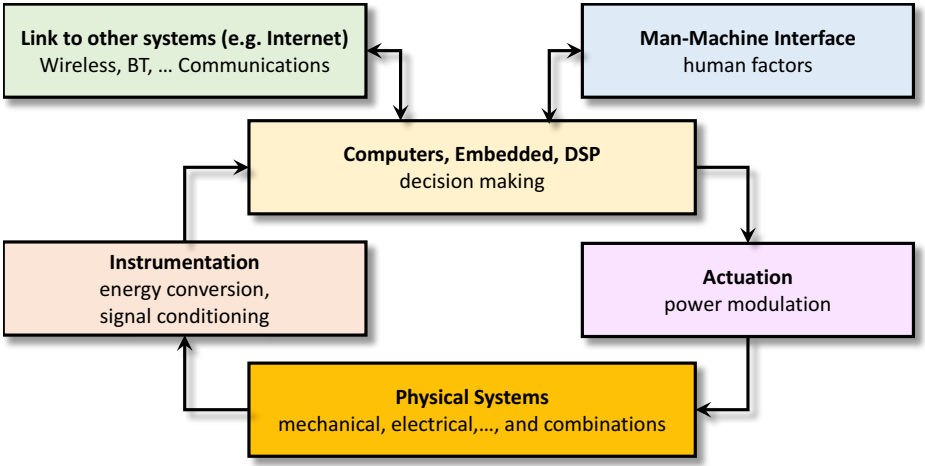
Class III:

- Systems that **retain the functionality of the traditional mechanical** system, **but the internal** mechanisms are **replaced by electronics**. An example is the digital watch.

Class IV:

- Products **designed with mechanical and electronic** technologies through synergistic **integration**. Examples: photocopiers, intelligent washers and dryers, and automatic ovens.

Modern Mechatronic System



Mechatronic Systems Examples

Mechatronic Systems

Mechatronic machine components

- semi-active hydraulic dampers
- automatic gears
- magnetic bearings

Mechatronic motion generators

- integrated electrical servo drives
- integrated hydraulic servo drives
- integrated pneumatic servo drives
- robots (multi-axis, mobile)

Mechatronic power producing machines

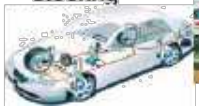
- brushless DC motors
- integrated AC drives
- mechatronic combustion engines

Mechatronic power consuming machines

- integrated multi-axis machine tools
- integrated hydraulic pumps

Mechatronic automobiles

- antilock brake (ABS)
- electro-hydraulic brake (EHB)
- active suspension
- active front steering



Mechatronic trains

- tilting trains
- active boogie
- magnetic levitated trains (MAGLEV)

Mechatronics Application Area

- Automation and robotics
- Computer aided and integrated manufacturing systems
- Computer Numerically Controlled machines
- Consumer products
- Diagnostic reliability and control system techniques
- Engineering design
- Engineering and manufacturing systems
- Industrial goods
- Packaging
- Expert systems
- Machine vision
- Medical systems
- Sensing and control systems
- Servo-mechanics
- Structural dynamic systems
- Systems engineering
- Transportation and vehicular systems
- Automotive engineering

The Development of Automobiles

- Until the 1960s, the radio was the only significant electronics in a car.
  - All other functions were entirely mechanical or electrical, such as the starter motor and the battery charging systems.
- Modeling of the combustion process showed that, for increased fuel efficiency, there existed an optimal time when the fuel should be ignited.
  - The timing depends on load, speed, and other measurable quantities.
- The electronic ignition system was one of the first mechatronic systems to be introduced in the automobile in the late 1970s.
  - The electronic ignition system consists of a crankshaft position sensor, camshaft position sensor, airflow rate, throttle position, rate of throttle position change sensors, and a dedicated microcontroller determining the timing of the spark plug firings.
- The Antilock Brake System (ABS) was also introduced in the late 1970s in automobiles
- The Traction Control System (TCS) was introduced in automobiles in the mid-1990s.

The Development of Automobiles

- Nowadays there are about 30-60 microcontrollers in each automobile. These processors are used for:
  - Engine management
  - Transmission control
  - Airbags
  - ABS, TCS, VDC,
  - Instrument cluster
  - Air conditioning systems
  - Seat, mirror control, and window lift systems.

Mechatronic System Example

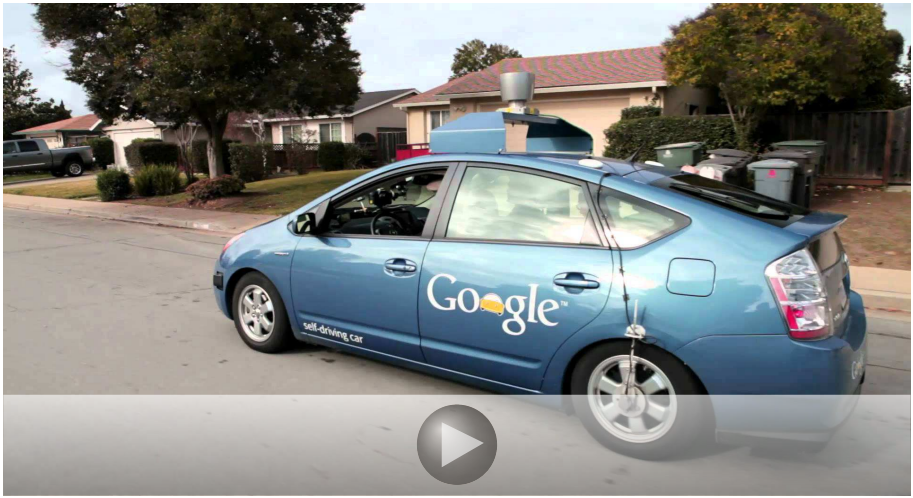
Automobiles

The Development of Automobiles

- New applications of mechatronic systems in the automotive world include:
  - Safety enhancements
  - Emission reduction
  - Intelligent cruise control
  - Drive and Brake by wire systems
  - Wireless networking of automobiles to ground stations and vehicle-to vehicle communication.
  - Telematics, which combines audio, hands-free cell phone,
- navigation, Internet connectivity, e-mail, and voice recognition
  - MEMS
- Semi-autonomous to fully autonomous automobiles

Autonomous Vehicle System

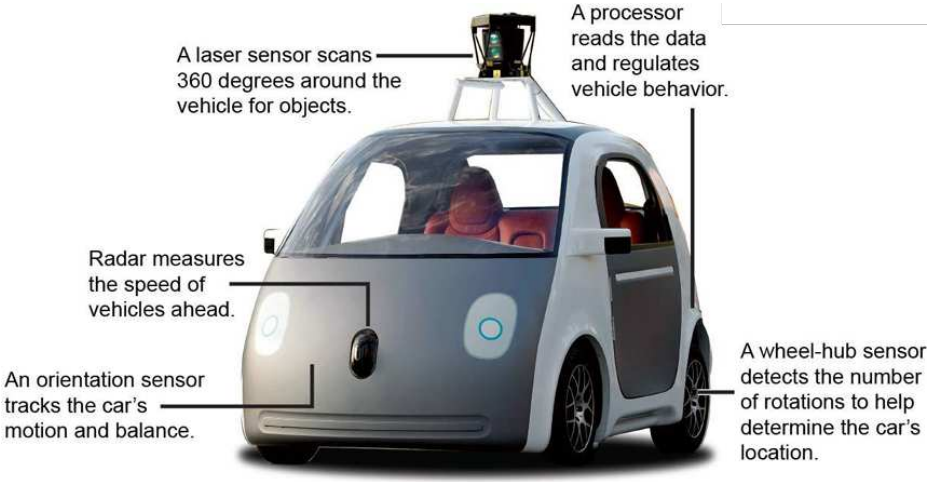
The Google self-driving car



TED 2015, https://www.youtube.com/watch?v=tiwVMrTLUWg

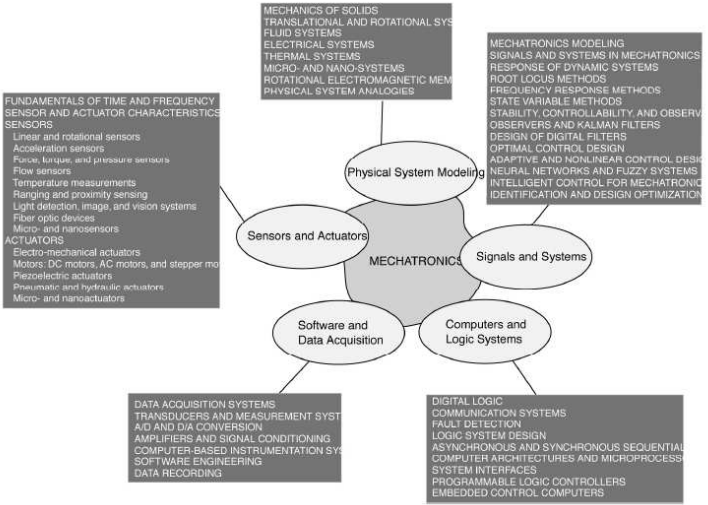
Autonomous Vehicle System

The Google self-driving car: Waymo



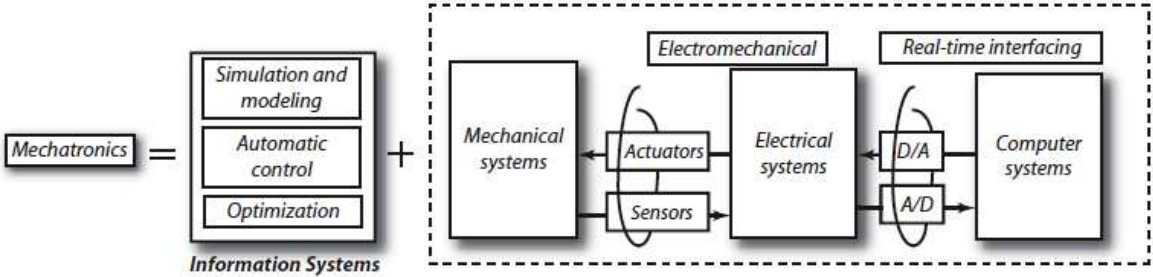
https://www.google.com/selfdrivingcar/

Elements of Mechatronic Systems

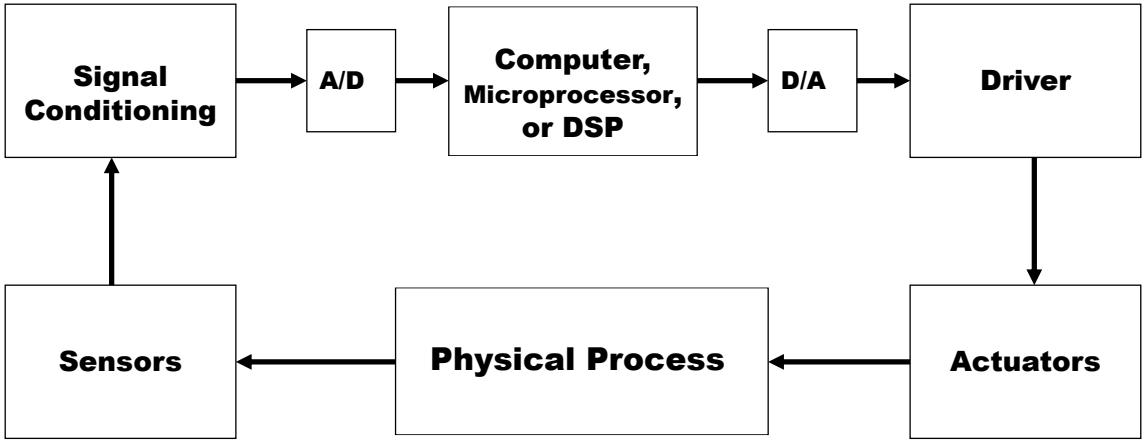


Robert H. Bishop, Mechatronic Systems, Sensors, and Actuators: Fundamentals and Modeling, CRC Press, 2007

Mechatronics Key Elements



Mechatronic Systems Block Diagram



Thanks for your attention.

Questions?

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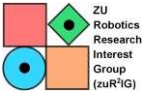

Robotics Research Interest Group (zuR^{2}IG)
Zagazig University | Faculty of Engineering | Computer and Systems Engineering Department | Zagazig, Egypt