Intro to Automation and Controls

Links:
https://www.calvin.edu/~pribeiro/courses/engr315/lectures-notes/
https://www.engr.siu.edu/staff/spezia/Web438A/Lecture%20Notes/ET38ANotes1.pdf

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Chapter 1: Introduction to Control Systems Objectives

In this chapter we describe a general process for designing a control system.

A control system consisting of interconnected components is designed to achieve a desired purpose. To understand the purpose of a control system, it is useful to examine examples of control systems through the course of history. These early systems incorporated many of the same ideas of feedback that are in use today.

Modern control engineering practice includes the use of control design strategies for improving manufacturing processes, the efficiency of energy use, advanced automobile control, including rapid transit, among others.

We also discuss the notion of a design gap. The gap exists between the complex physical system under investigation and the model used in the control system synthesis.

The iterative nature of design allows us to handle the design gap effectively while accomplishing necessary tradeoffs in complexity, performance, and cost in order to meet the design specifications.

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Introduction

System – An interconnection of elements and devices for a desired purpose.

Control System – An interconnection of components forming a system configuration that will provide a desired response.

Process – The device, plant, or system under control. The input and output relationship represents the cause-and-effect relationship of the process.

Process to be controlled.

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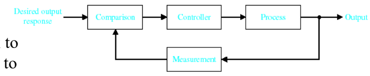
Introduction

Open-Loop Control Systems utilize a controller or control actuator to obtain the desired response.

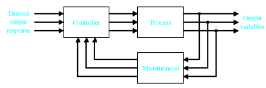
Open-loop control system (without feedback).

Closed-Loop Control Systems utilizes feedback to compare the actual output to the desired output response.



Closed-loop feedback control system (with feedback).

Multivariable Control System



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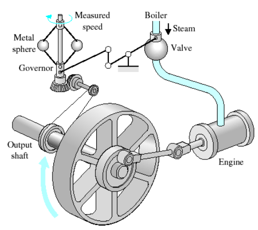
History

Greece (BC) – Float regulator mechanism
Holland (16th Century)– Temperature regulator



Watt's Flyball Governor (18th century)

See: https://www.youtube.com/watch?v=HS_YGZXP2xY

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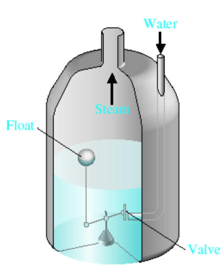
History

Water-level float regulator



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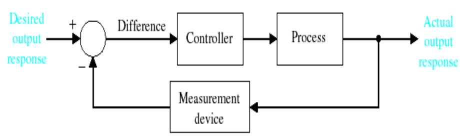
History



Closed-loop feedback system.

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History

18th Century James Watt's centrifugal governor for the speed control of a steam engine.

1920s Minorsky worked on automatic controllers for steering ships.

1930s Nyquist developed a method for analyzing the stability of controlled systems

1940s Frequency response methods made it possible to design linear closed-loop control systems

1950s Root-locus method due to Evans was fully developed

1960s State space methods, optimal control, adaptive control and

1980s Learning controls are begun to investigated and developed.

Present and on-going research fields. Recent application of modern control theory includes such non-engineering systems such as biological, biomedical, economic and socio-economic systems

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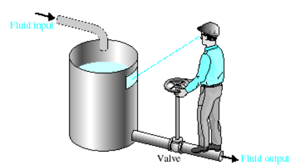
Examples of Modern Control Systems



A manual control system for regulating the level of fluid in a tank by adjusting the output valve. The operator views the level of fluid through a port in the side of the tank.

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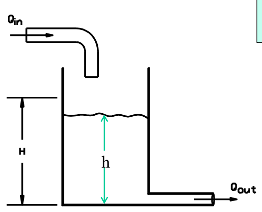
The Control Problem

Fundamental Control Concepts

Maintain a variable of process at a desired value while rejecting the effects of outside disturbances by manipulating another system variable.



Q_{out} depends on h
If $Q_{out} = Q_{in}$, h constant
$Q_{out} > Q_{in}$, tank empties
$Q_{out} < Q_{in}$, tank overflows

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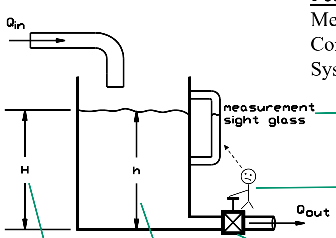
Basic Subsystems of Control

Feedback Control Subsystems
Measurement
Control decision
System modification



Measurement- sight glass

Control Decision Human adjusts Q_{out} to maintain h =H

Reference (setpoint) h = control variable

Process- Maintain tank level

Final Control Element Valve

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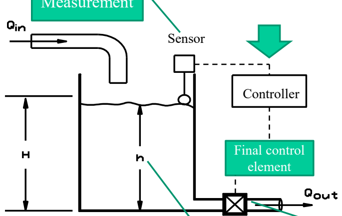
Automatic Control Systems

Use sensors and analog or digital electronics to monitor and adjust system

Level Measurement



Elements of Automatic Control
Process – single or multiple variables
Measurement – sensors
Error Detection – compare H to h
Controller – generate corrections
Final Control Element – modify process

Maintain level

Valve Position

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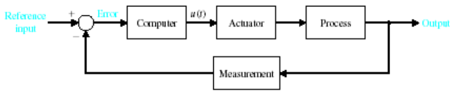
Examples of Modern Control Systems



A computer control system.

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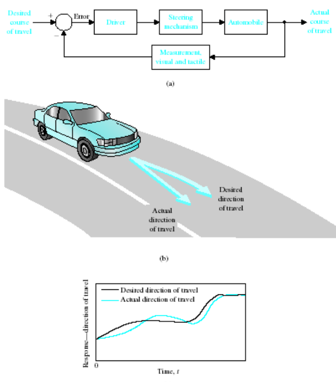
Examples of Modern Control Systems



(a) Automobile steering control system.

(b) The driver uses the difference between the actual and the desired direction of travel

to generate a controlled adjustment of the steering wheel.

(c) Typical direction-of-travel response.

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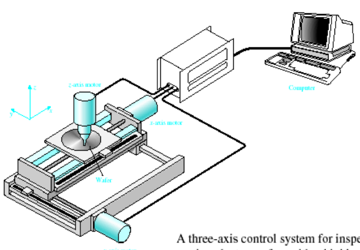
Examples of Modern Control Systems



A three-axis control system for inspecting individual semiconductor wafers with a highly sensitive camera.

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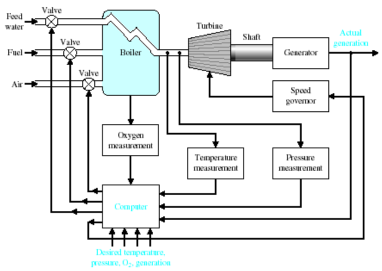
Examples of Modern Control Systems



Coordinated control system for a boiler-generator.

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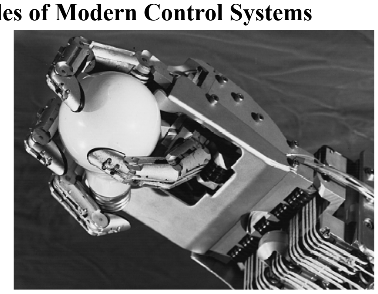
Examples of Modern Control Systems



The Utah/MIT Dextrous Robotic Hand: A dextrous robotic hand having 18 degrees of freedom, developed as a research tool by the Center for Engineering Design at the University of Utah and the Artificial Intelligence Laboratory at MIT. It is controlled by five Motorola 68000 microprocessors and actuated by 36 high-performance electropneumatic actuators via high-strength polymeric tendons. The hand has three fingers and a thumb. It uses touch sensors and tendons for control. (Photograph by Michael Milochik. Courtesy of University of Utah.)

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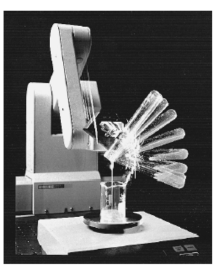
Examples of Modern Control Systems



A laboratory robot used for sample preparation. The robot manipulates small objects, such as test tubes, and probes in and out of tight places at relatively high speeds [41]. (© Copyright 1993 Hewlett-Packard Company. Reproduced with permission.)

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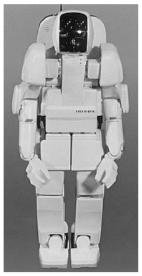
The Future of Control Systems



The Honda P3 humanoid robot. P3 walks, climbs stairs and turns corners.
Photo courtesy of American Honda Motor, Inc.

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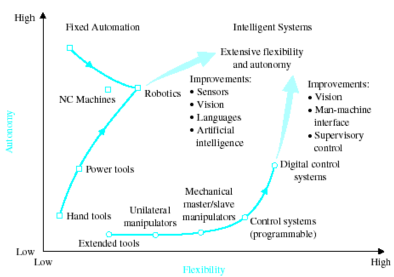
The Future of Control Systems



Future evolution of control systems and robotics.

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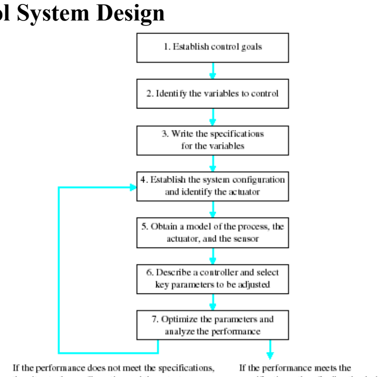
Control System Design



The control system design process.

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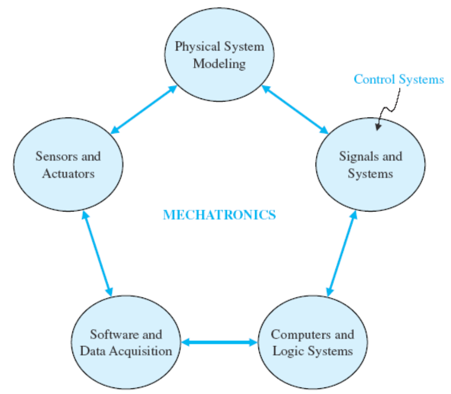

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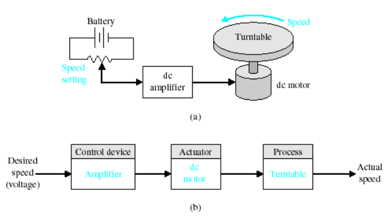
Design Example



(a) Open-loop (without feedback) control of the speed of a turntable.
(b) Block diagram model.

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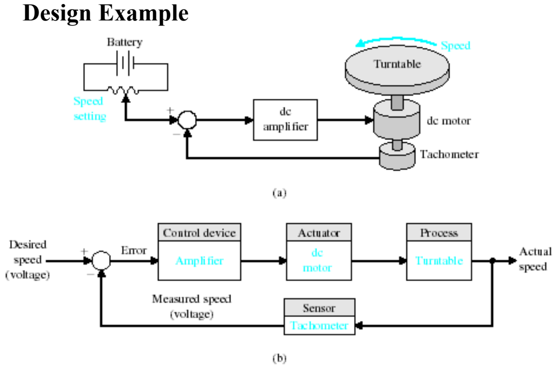
Design Example



(a) Closed-loop control of the speed of a turntable.
(b) Block diagram model.

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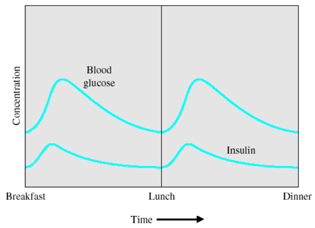
Design Example



The blood glucose and insulin levels for a healthy person.

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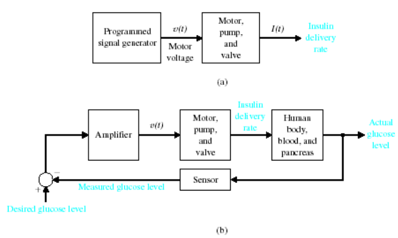
Design Example



(a) Open-loop (without feedback) control and
(b) closed-loop control of blood glucose.

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F-22 Raptor Crash Landing

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References, and Resources

http://www.ieeecss.org/siteindex/SITEindex.html

http://www-control.eng.cam.ac.uk/extras/Virtual_Library/Control_VL.html

https://www.engr.siu.edu/staff/spezia/Web438A/Lecture%20Notes/ET38A Notes1.pdf

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