

Everything Under Control?

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Outline

- **Basics of control**
 - principle of feedback
 - systems we have under control
- **Emerging applications**
 - traffic and transport
 - driver assistance
- **Current research trends and challenges**
 - where the current methods fall short . . .

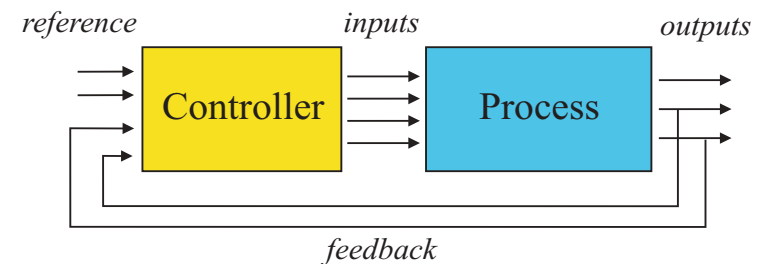
What is Automatic Control?

principles and methods used to design systems that

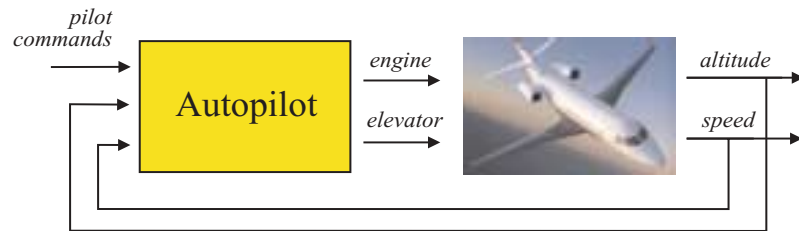
- maintain desirable performance
- despite external disturbances and
- changes in the controlled system or its environment

Main principle: feedback of a measured quantity, influence the behavior of a system through computation and actuation

Elements of Control

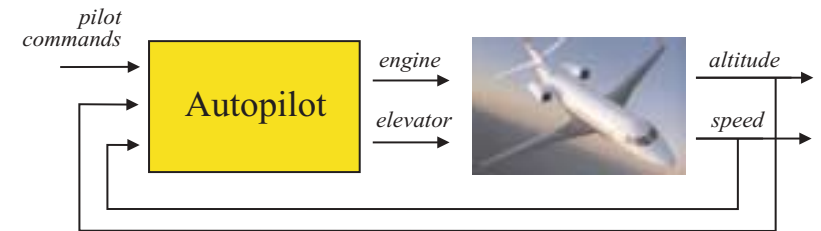


Example: Aircraft Autopilot



- + improved comfort, handling, safety
- + lower fuel consumption
- + integrated design of aircraft and control systems

Example: Aircraft Autopilot



- increased cost (hardware, design effort)
- fail-safe performance required, certification
- pilot not completely in charge

Evolution of Control

roots in the industrial revolution, huge progress in last 40–50 years

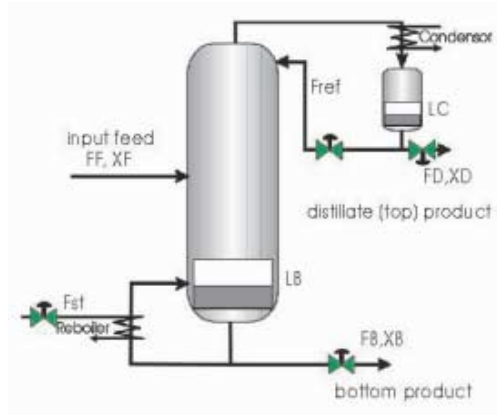
- breakthroughs in the underlying principles and mathematics
- improvements in sensing (inexpensive, ubiquitous sensors)
- computers systems (embedded, networked, distributed)
- drive for better performance, environmental issues, etc.

Applications of Control

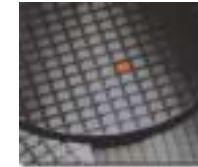
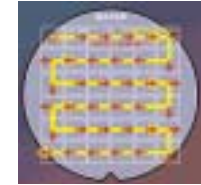
Control systems are invisible, but omnipresent in a vast number of processes and products:

- industrial processes, manufacturing, robots
- consumer goods, home appliances, CD players
- computers, networks, communication systems
- transportation systems: cars, planes, spacecraft

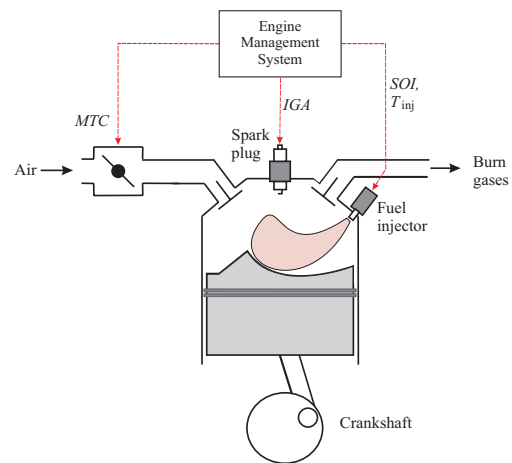
Chemical Processes



Integrated Circuits Manufacturing



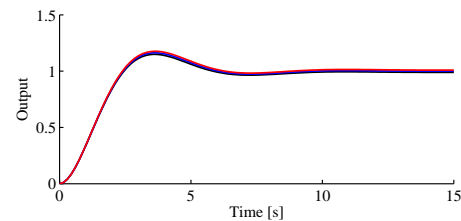
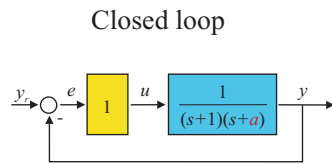
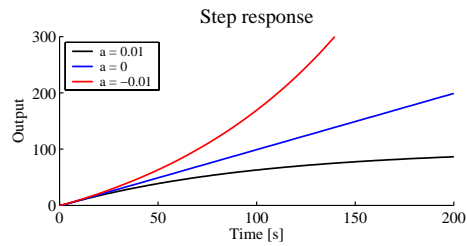
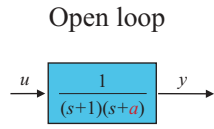
Engine Management Systems



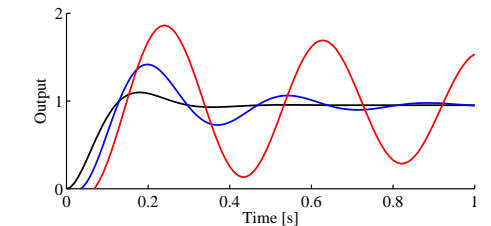
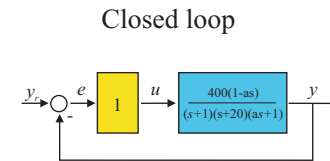
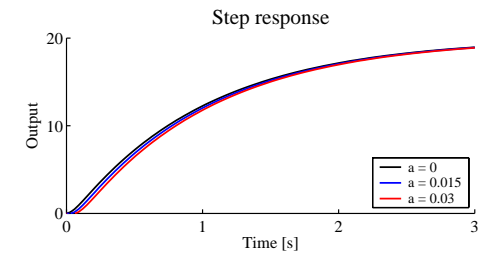
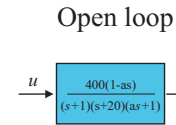
X-by-Wire Systems



The 'power' of feedback ...

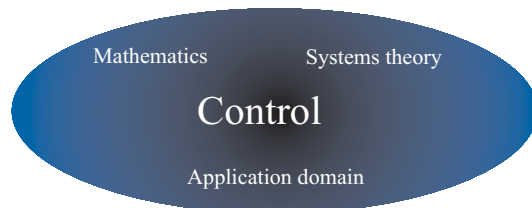


...but, there are pitfalls too



Cornerstones of Control

- need to understand dynamics, analyze complex systems
- develop provably correct techniques for the design
- rigorous use of and contributions to mathematics
- education and training using "systems-oriented approach"



Example of an Emerging Application Field

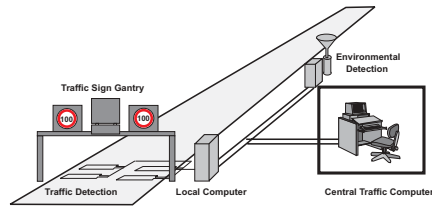
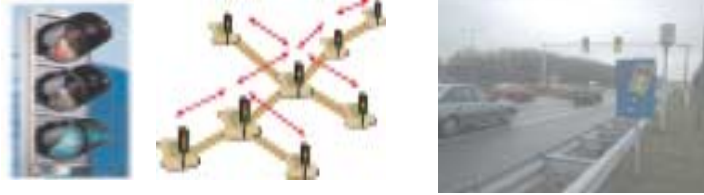
Traffic and transportation systems

- increased mobility of people and goods
- concerns about safety and environmental impact
- capacity and efficiency

Control at various levels

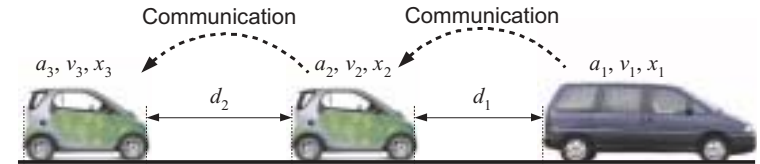
- vehicle control and driver assistance
- control traffic flow in transportation networks
- air traffic management (dispatching, approach control)

Traffic Flow Control



CarTALK Project

Communication Based Longitudinal Vehicle Control



- A recent M.Sc. graduation project of Redouane Hallouzi
- Collaboration with TNO Automotive

Driver Assistance Systems

- **Improvement of safety and comfort** by Adaptive Cruise Control and Stop&Go systems with radar sensors in current cars
- Novel in the current project: **inter-vehicle communication**
- Possible **driver-assistance applications**:
 - Information and warning functions
 - Communication-based longitudinal control
 - Co-operative driver assistance

Demonstration Cars

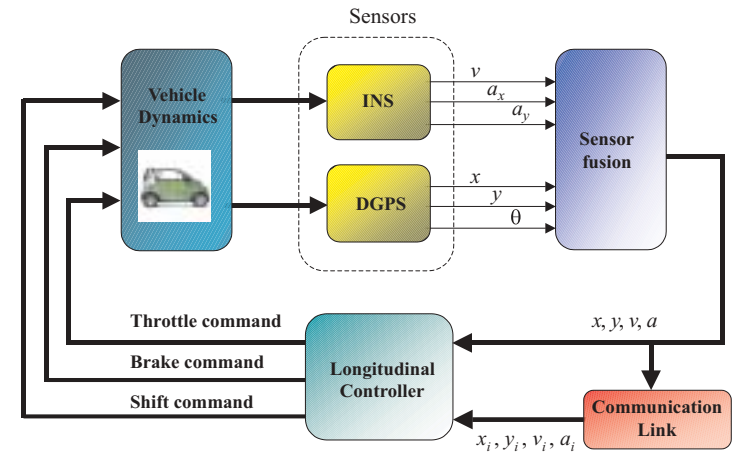


Control Hardware

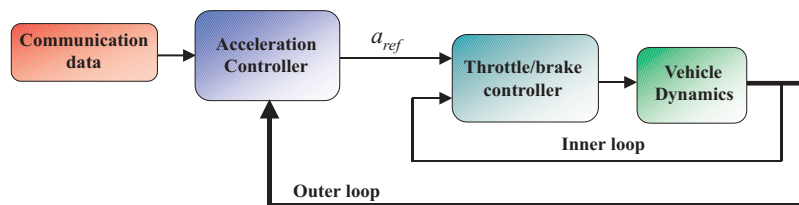


- **Sensors:** accelerometer and odometer (INS), DGPS
- **Actuators:** electronically controlled throttle and gearbox, brake actuator with brake pedal position sensor
- **Control computer:** PC-104 using real-time Linux

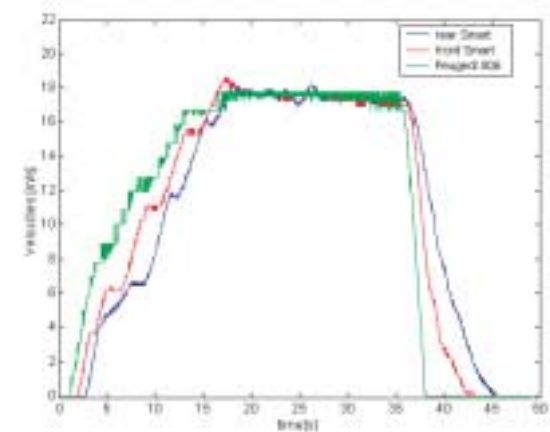
Closed-Loop System Modules



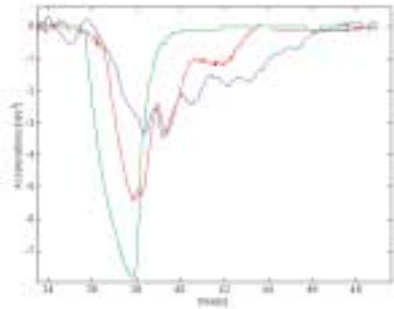
Control Scheme



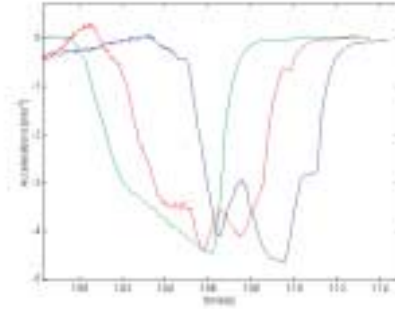
Typical Test Results – Stop & Go



Test Results – Automatic vs. Manual Braking



automatic



manual

Current Research Trends in Control

- **Accounting for uncertainty**
 - traditional linear models are not accurate enough
 - represent the system by a linear model and the associated uncertainty, design a robust controller
- **Nonlinear systems**
 - use more accurate, detailed models
 - difficulty: they are hard to obtain
- **Learning and adaptive control**
 - no model available
 - controller 'learns' by experience