Automation, Control, Control Engineering and Control Science

A Motivation

Professor Günther Schmidt
TU München

Automation

- Technique of making an apparatus, a machine, a process or a system operate **automatically**, i.e. often by partial or total replacement of the human element

- Two major aspects of automation
  * **Mechanization** of an operation
  * **Control, coordination** and **integration** of operations by means of techniques from the areas of control, communication and IT

❖ A Remarkable Early Book on Automation

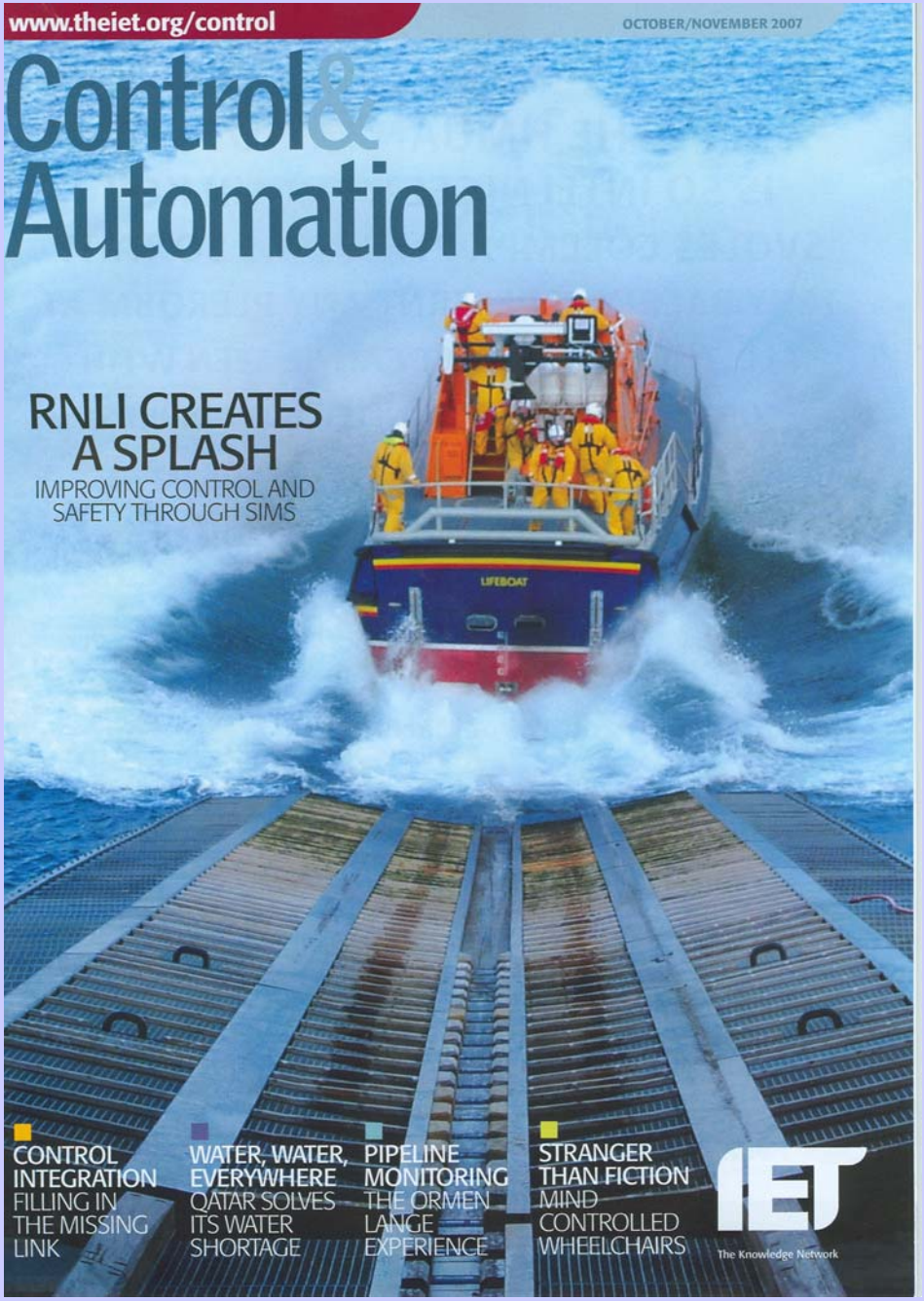
AUTOMATION

The Advent of the Automatic Factory

JOHN DIEBOLD

D. VAN NOSTRAND COMPANY, INC.
PRINCETON, NEW JERSEY
TORONTO LONDON
NEW YORK

Contents


www.theiet.org/control
OCTOBER/NOVEMBER 2007
Control & Automation
RNLI CREATES A SPLASH
IMPROVING CONTROL AND SAFETY THROUGH SIMS
LIFEBOAT
CONTROL INTEGRATION
FILLING IN THE MISSING LINK
WATER, WATER, EVERYWHERE
QATAR SOLVES ITS WATER SHORTAGE
PIPELINE MONITORING
THE ORMEN LANGE EXPERIENCE
STRANGER THAN FICTION
MIND CONTROLLED WHEELCHAIRS
IET
The Knowledge Network

Control: Principles

Control Engineering: Implementation Issues

Control Science: Mathematical Foundations

❖ Feedback – A crucial ingredient of control

Feedback is a universal principle of nature,
e.g. natural evolution, trial-and-error, greenhouse effect, ….

- Invented and intuitively applied by humans
  for purposes of control,
  i.e. **artificial feedback** = feedback control

- and later discovered in nature,
  i.e. **natural feedback**.

- Often re-invented and refined by engineers
  over the last 250 years

❖ Early Feedback Control System

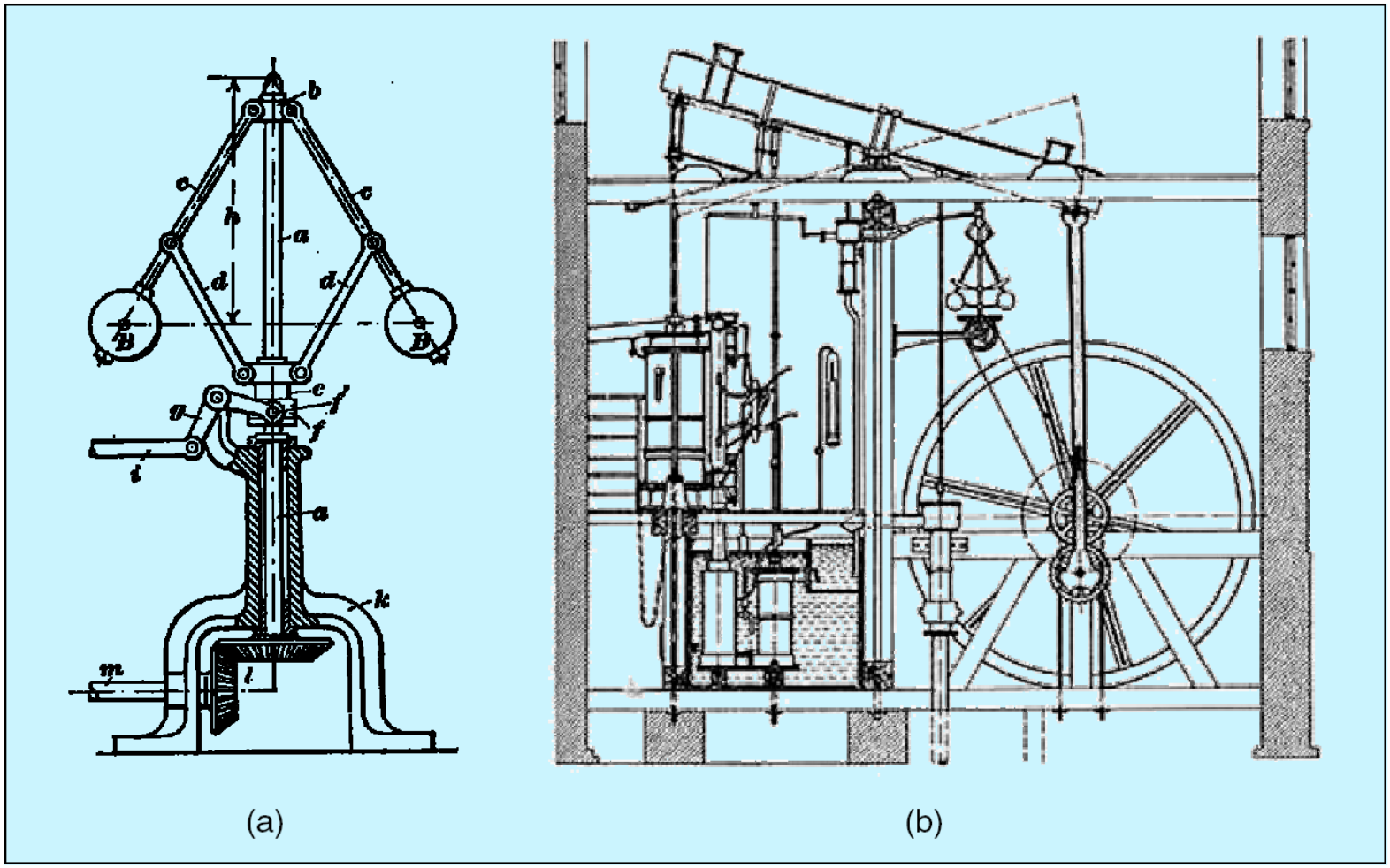


Figure 1. *(a) The centrifugal governor, developed in the 1780s, was an enabler of (b) the successful Watt steam engine, which fueled the industrial revolution. (Figures courtesy Richard Adamek (copyright 1999) and Cambridge University.)*

❖ A Remarkable Early Book on Control Science

CYBERNETICS

OR CONTROL AND COMMUNICATION IN THE ANIMAL AND THE MACHINE

Norbert Wiener
PROFESSOR OF MATHEMATICS
THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE TECHNOLOGY PRESS
JOHN WILEY & SONS, INC., NEW YORK
HERMANN et CIE, PARIS

CONTENTS

❖ Sample Characterizations of Control

- **"Hidden Technology"** (Aström):
  Embedded in technological, biological, socio-economic and many other man-made systems

- **"Enabling Technology"**
  for numerous application areas

- **"Make things work better or sometimes even work at all"**
  (Control Professional)

- **"Use of algorithms and feedback in engineered systems"**
  (2003 Panel on Future of Control)

- **“Out of control . . . . “**
  (Title of a book)

➢ ***“Confidence may be good, but control is better“***
(Lenin)

Note different semantics
of the term “control“, when used
in technology, economy, politics or daily life

➢ **”Don’t wait for the future – control it”**

❖ Where/What ?

- Anytime - anywhere, pervasive, ubiquitous
- Daily life devices
- *HiTech* and *CleanTech* products,
  generation, manufacturing, processing,
  traffic, transportation, agriculture ……..
- Instruments
- Human body and biology
- Society, economy, ecology, climate
- ……

❖ Why *Automatic* Control? - Benefits

- Reduce human fatigue and stress (mental and physical)
- Cope with substantial reaction times or limited strength of humans
- Assure reproducability and safety
- Increase convenience and quality of life
- Operate at the limits (economy)
- Stabilize unstable systems/processes/behaviours
- Modify natural dynamic behaviour
- Cope with uncertainties through feedback (robustness)
- .....

❖ Types of Controls ?

- Manual/human
- Automatic
- Shared
- Active/passive
- Computer/microprocessor
- Closed or open loop
- Feedback/feedforward
- Single/multiple loop
- Continuous, discontinuous, discrete/logical or hybrid
- PID or switching, on-off
- Analogue/digital
- Centralized/decentralized
- Fuzzy/neural
- Predictive/preview
- Hierarchical
- Embedded
- Adaptive
- Intelligent, cognitive
- Autonomous (perception-based)
- . . . . . .

❖ How to deal with ?

- "Understand, analyze, model, simulate the function and dynamics of the object to be controlled and work out (synthesize) appropriate (technical) means for achieving performance according to given control specifications"

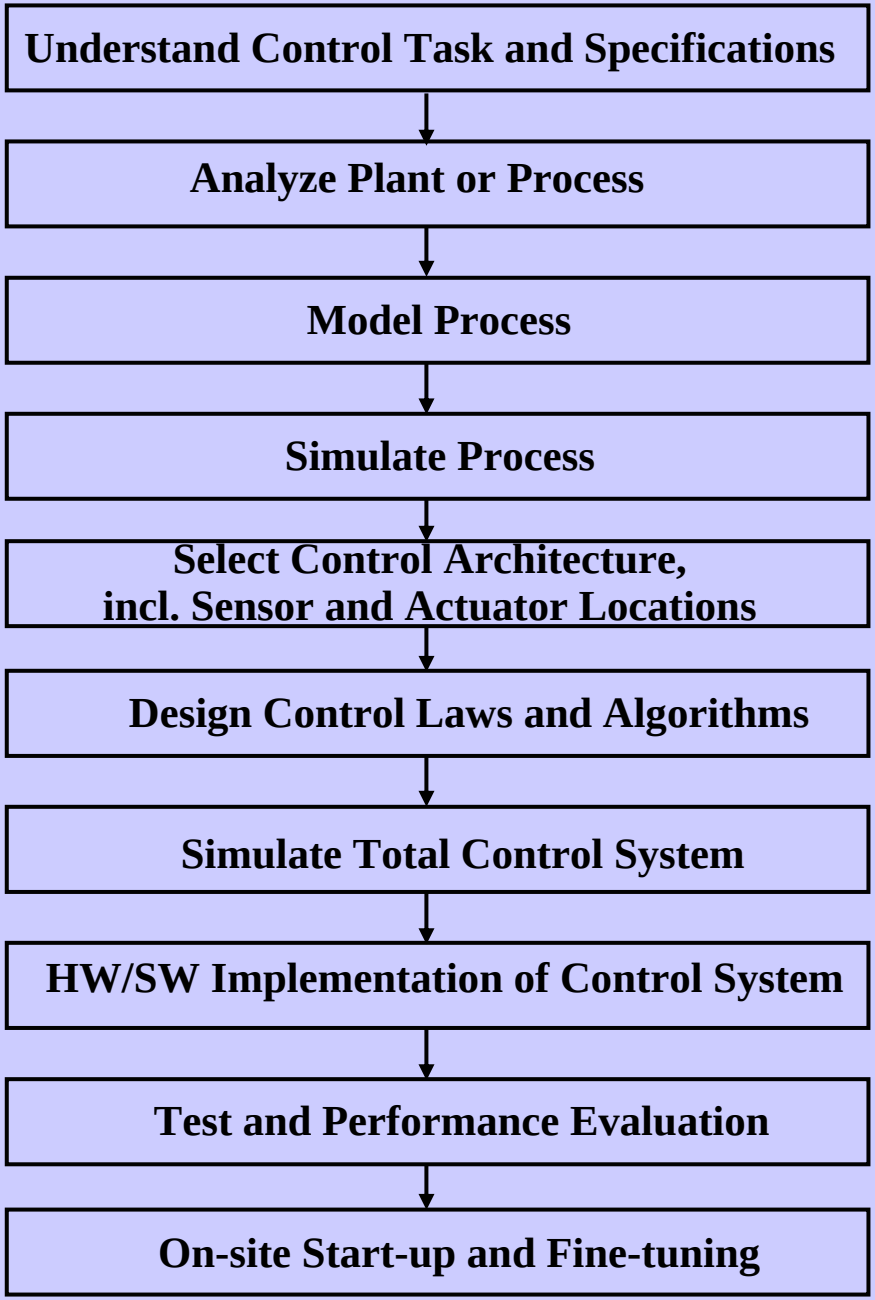
- Implementation depending on current HW & SW technology and specific requirements of application field

- Broad spectrum of standard industrial components and systems: sensors, actuators, control computers, SW packages …….

- Excellent theories, methodologies and efficient CACSD tools, e.g. *MATLAB* & code generators, available

- Methodological background for analysis and synthesis to a great extent **independent of current technology and specific application area**

❖ Steps of Control System Development



❖ Trends and Challenges ?

- Novel areas and challenges need new efforts and approaches in systems and control, automation ……
  To be discussed in more detail during this lecture series!

❖ Ultimate Objective of this Lecture ?

- Apply systems and control ideas, concepts or techniques in your job and capitalize by adopting the ***"systems perspective"***
- Develop models, understand system dynamics and feedback
- Reduce time delays and latencies in all kinds of closed loop operations and activities for stability and better performance
- Close as many (information or feedbck) loops as possible for improved performance and higher degrees of robustness
- Team up with control experts in an early phase of a project
- Put new knowledge into action