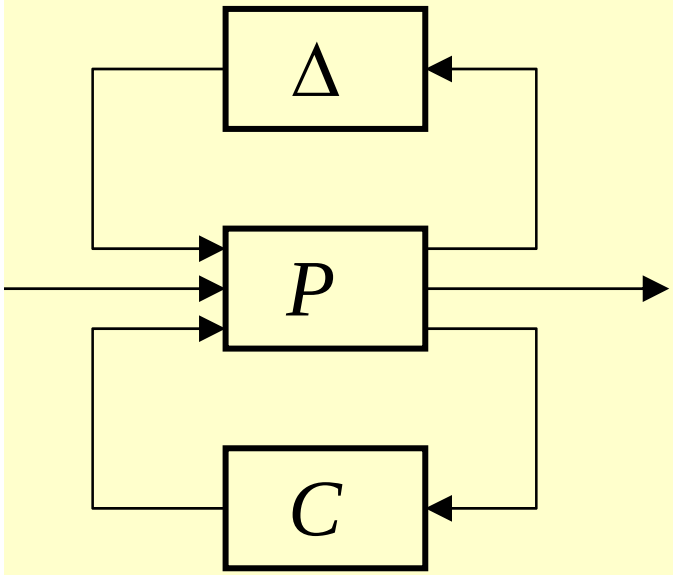
IFAC TECHNICAL BOARD

EMERGING AREAS IN CONTROL THEORY

CC 1: Systems and Signals
CC 2: Design Methods



Ruth Bars, CC2
Xi Ren Cao, CC1

ROLE OF THEORY

- Control theory needs to answer the important problems presented earlier.
- But theory also is responsible for discovering new opportunities for innovation and new vistas for humanity. New technologies, new application fields require new theories for modelling, analysis and design.
- Theory may take a long time to emerge, or hopefully be invented tomorrow.

Theory traditionally focuses on domains reflected in the TC structure of CC1 and CC2

Systems and Signals (CC1)

- (1.1) Modelling, Identification and Signal Processing
- (1.2) Adaptive and learning systems
- (1.3) Discrete Event and Hybrid Systems
- (1.4) Stochastic Systems
- (1.5) Networked Hybrid Systems

Design Methods (CC2)

- (2.1) Systems Control Design
- (2.2) Linear Control Systems
- (2.3) Non Linear Control Systems
- (2.4) Optimal Control
- (2.5) Robust Control

EMERGING TRENDS

In modelling and control there is a need for improved performance, better models, better methods for handling uncertainty, complexity, stability,boundedness, nonlinearity, overcoming random disturbances, challenge of applying the techniques to real applications such as networked systems.

SOME OF CURRENT PROBLEMS, ACHIEVEMENTS, TRENDS

- Interplay between identification and control
- Identification of nonlinear systems, techniques from machine learning

CHALLENGE

- Powerful new linear system identification tools needed to model large scale systems
- Data based identification techniques, data mining, converting data into knowledge

SOME OF CURRENT PROBLEMS, ACHIEVEMENTS, TRENDS

- Adaptive control with assurance of stability and robustness
- Nonlinear adaptive control adopting multiple models using multiple controllers
- Internal model control better understood and applied

CHALLENGE

- Adaptive control of large distributed networked systems with variable delays, adaptive control of micro and nano scale systems

SOME OF CURRENT PROBLEMS, ACHIEVEMENTS, TRENDS

- Unifying system and control theory for discrete event systems incorporating both time-driven and event-driven dynamics
- Fault diagnosis

CHALLENGE

- ”Complexity” demands deeper understanding
- Large scale systems, decentralized and distributed control schemes, embedded systems and sensor networks will foster the convergence of control, computing, communication, networking
- Modelling, analysis and control of large interconnected dynamical systems with hybrid decision variables

SOME OF CURRENT PROBLEMS, ACHIEVEMENTS, TRENDS

- Stochastic modelling of complex systems (large scale systems with communication constraints)

  Advances in description of complex manufacturing systems, communication networks
- Use of image and speech processing, computational vision
- Trajectory optimisation of moving objects under changing environment, learning in 2D, 3D space

CHALLENGE

- New developments in the technology of sensors and actuators will continue to fertilize new control application fields (e.g. medicine, biology, crystallography, etc.)

  All these fields need new efforts for modelling, analysis and design.

Numerical techniques

Examples:

- Randomized methods for optimal identification and control of complex uncertain systems
- Linear semi-definite programming, interior point algorithms, LMI design, BMI optimisation, software available
- Application of nonsmooth nonconvex optimisation techniques to solve difficult design problems (using publicly available user-friendly software)
- Mixed integer optimisation programming methods
- Interplay between algebra, geometry and convex analysis with applications in control
- Utilising of subspace methods for data collected under feedback
- Reliable implementation of optimal and robust control algorithms, pre-conditioning techniques

Methodologies and implementations

- Integrated modelling-control-optimisation to cover all the phases of life-cycle of real systems
- Model Predictive Control, receding horizon strategies
- Smart sensor and decision networks with embedded prognostics and predictive mechanisms, employing fuzzy-neural-analytical and bio-inspired approaches
- Autonomic (autonomous-automatic) computing, risk analysis, and conversion of information to knowledge
- Integrated e-work and collaboration technology, telecontrol and telepresence
- Reference models and their underlying methodologies (e.g. ontology-based,semantic enriched, collaboration protocols) for establishing interoperability

Role of education