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Challenges in Control

A tribute to LIDS and Sanjoy

K. J. Åström
Department of Automatic Control
Lund University



Proceedings IBM Scientific Computing Symposium Control Theory and Applications

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IBM Corporation, White Plains, New York

Session Chairmen

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Princeton, New Jersey

SESSION II

LEFSCHETZ, S., Professor, Brown University,
Providence, Rhode Island

SESSION III

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Brooklyn, New York

SESSION IV

COURANT, R., Professor Emeritus, Courant Institute of
New York University, New York, New York

SESSION V

MOSER, J., Professor, Courant Institute of Mathematics,
New York University, New York, New York

Research Technical Adviser

GOLDSTINE, H. H., Director of Mathematical Sciences,
Thomas J. Watson Research Center, IBM Corporation,
Yorktown Heights, New York

Symposium Technical Planning Committee

COHEN, H. G., Research Staff Member, IBM Corporation,
Yorktown Heights, New York

EATON, J. H., Manager, Control Systems, IBM Corporation,
San Jose, California

GAZIS, D. C., Thomas J. Watson Research Center, IBM Corporation,
Yorktown Heights, New York



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- 1 Optimal Programming and Control —ARTHUR E. BRYSON, JR.
- 2 Toward a Theory of Difficulty of Computation in Optimal Control —R. E. KALMAN
- 3 Some Aspects of the Relationship of Dynamic Programming to the Calculus of Variations —STUART E. DREYFUS

SESSION II: Theory and Computations II

- 4 On Certain Differential Games —L. S. PONTRYAGIN
- 5 Applications of Liapunov Stability Theory to Control Systems —J. P. LASALLE
- 6 Stability of the Optimal Control Problem —LAWRENCE MARKUS

SESSION III: Industrial Processes

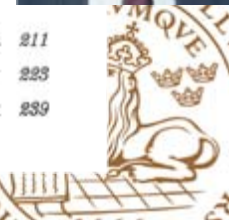
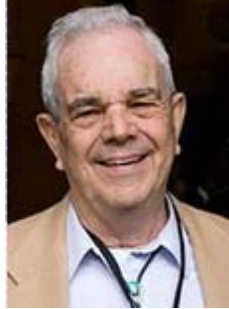
- 7 Application of Optimal Methods to Control of Industrial Processes —J. H. WESTCOTT
- 8 Control Theory and Applications in Chemical Process Control —THEODORE J. WILLIAMS
- 9 Control Problems in Papermaking —K. J. ÅSTRÖM

SESSION IV: Special Processes

- 10 Control Problems in Automobile Traffic —DENOS C. GAZIS
- 11 Application of Control Theory to Biological Systems —FRED S. GRODINS
- 12 Minimum-Fuel Impulses for Space Trajectories —LUCIEN W. NEUSTADT

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A Perspective

➤ Emergence

Drivers: World War II

Formation of the field

The Servomechanisms Laboratory 1940



➤ The Second Phase

Drivers: Space race, computer control

Subspecialization: ...



➤ The Third Phase?

Drivers: Complex networked systems,

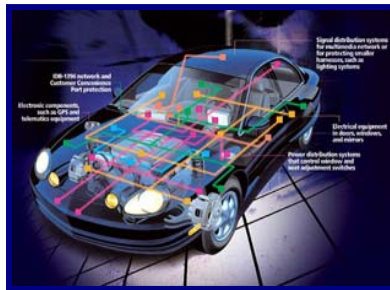
Safe embedded systems

Autonomy

Recover the holistic view



Control Everywhere



The Power of Feedback

- Accurate systems from imprecise components
- Reduce effects of disturbances and component variations
- Regulate, stabilize, and shape behavior
- Drawbacks:

Risk of Instability

Sensor noise is fed into the system



A Third Phase?

- Drivers: embedded systems, networks, biology, physics, economy ...
- Autonomous distributed systems
- Sensor and actuator rich systems
- Provable safe design and reconfiguration
- Can the holistic view be recovered?



Physics

➤ Nobel Prizes

Dahlén 1912

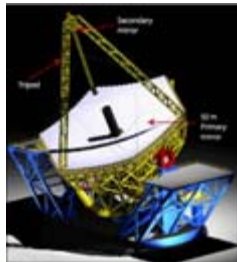
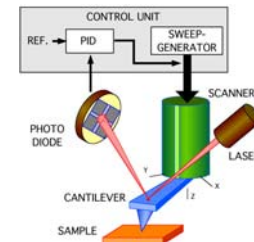
van der Meer 1984

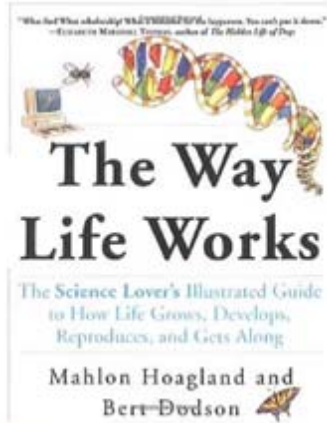


➤ Instruments mega to nano

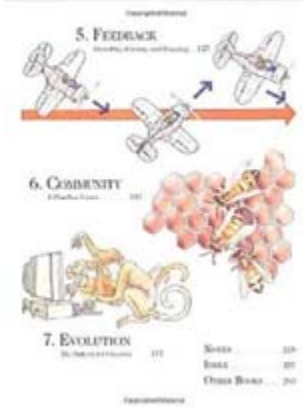
➤ Turbulence

➤ Quantum and molecular systems





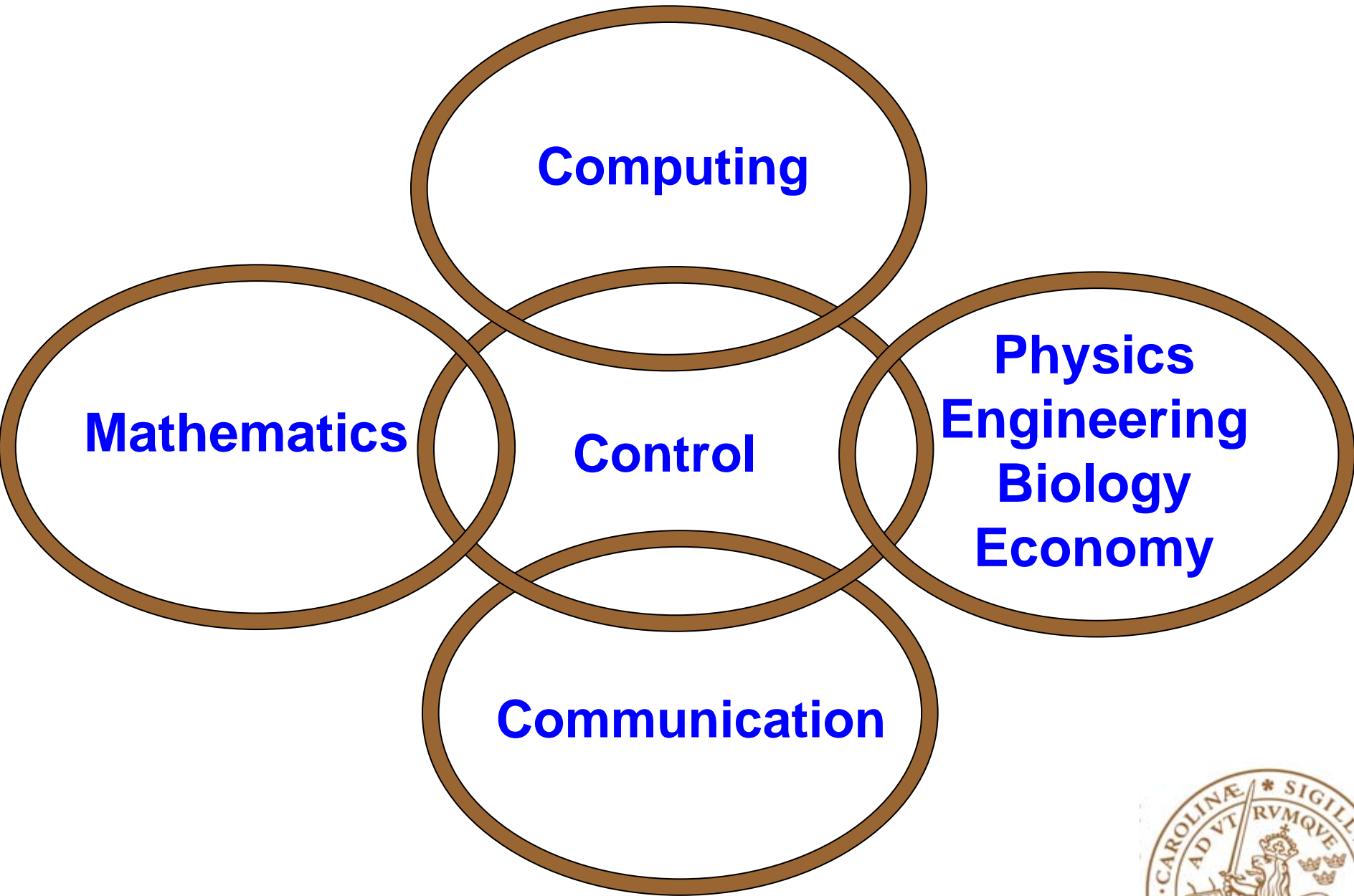
Biology



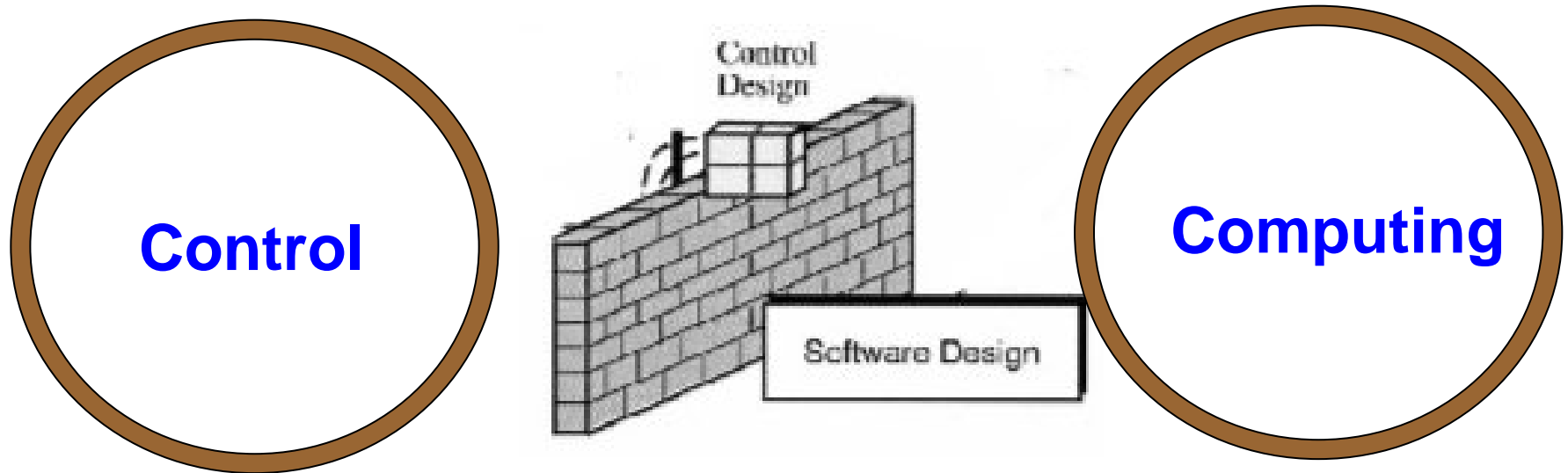
Feedback is a central feature of life. The process of feedback governs how we grow, respond to stress and challenge, and regulate factors such as body temperature, blood pressure, and cholesterol level. The mechanisms operate at every level, from the interaction of proteins in cells to the interaction of organisms in complex ecologies.

Mahlon B Hoagland and B Dodson The Way Life Works Times Books 1995





The CS Barrier



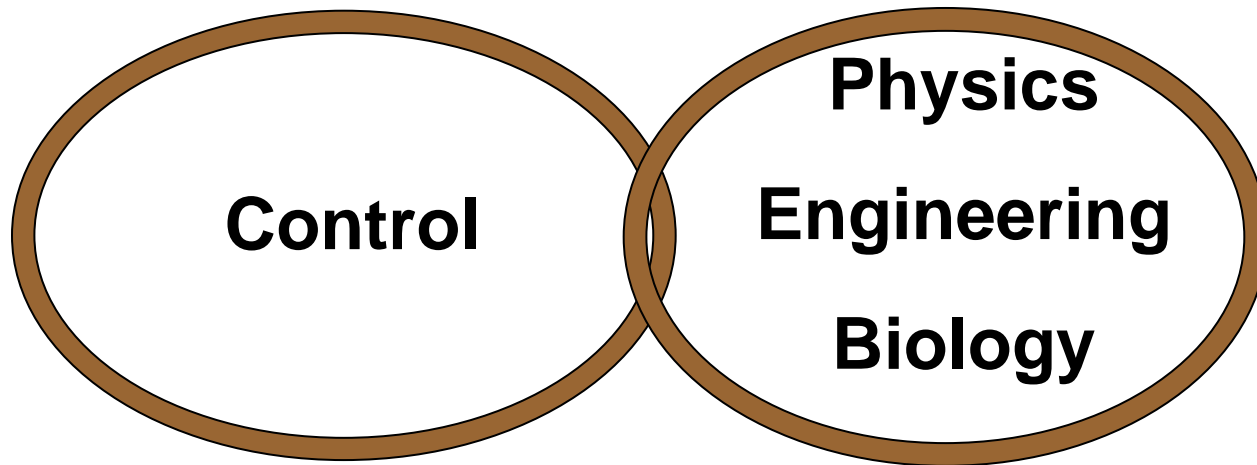
*Feedback, Stability, ODE, PDE
Moderate complexity
Robustness*

*Logic, languages, DES, FSM
High complexity, abstractions
Architecture*

The controller



The Physics Barrier



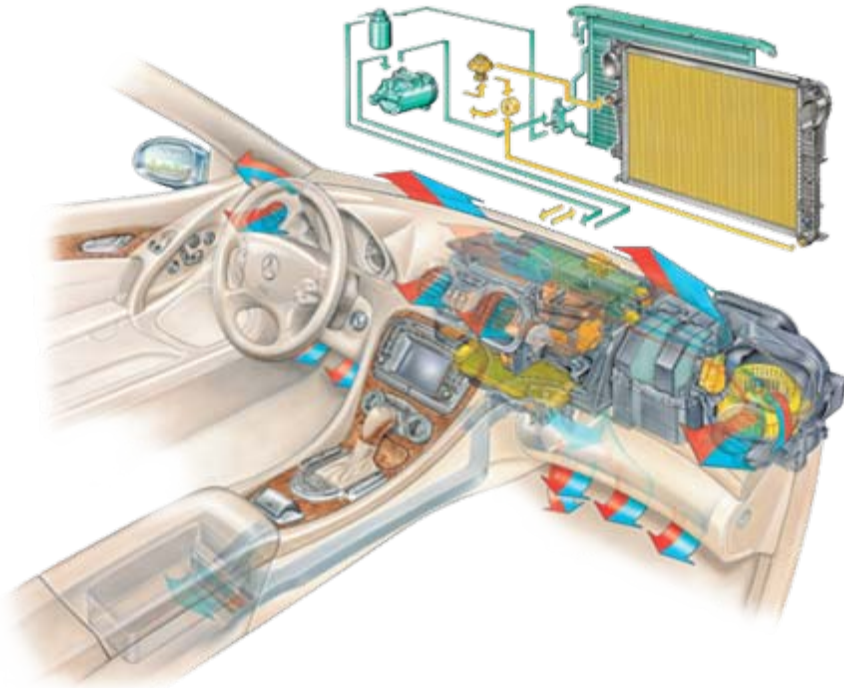
Blockdiagrams ODEs

Mass, energy, momentum

Block diagrams unsuitable for serious physical modeling



Automotive Climate Control



- Audi, BMW, DaimlerCrysler, Volkswagen and their suppliers have standardized on Modelica
- Suppliers provide *components and validated Modelica models* based on the AirConditioning library from Modelon
- Car manufacturers evaluate complete system by simulation
- IP protected by extensive encryption

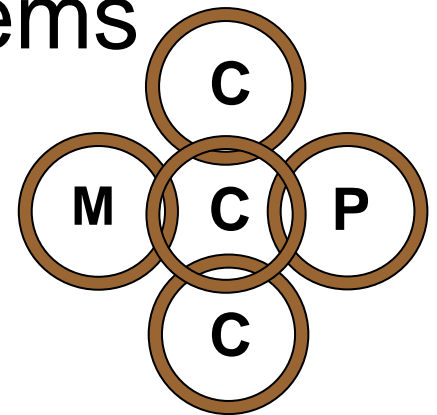
Picture courtesy of Behr GmbH & Co.

Modelon

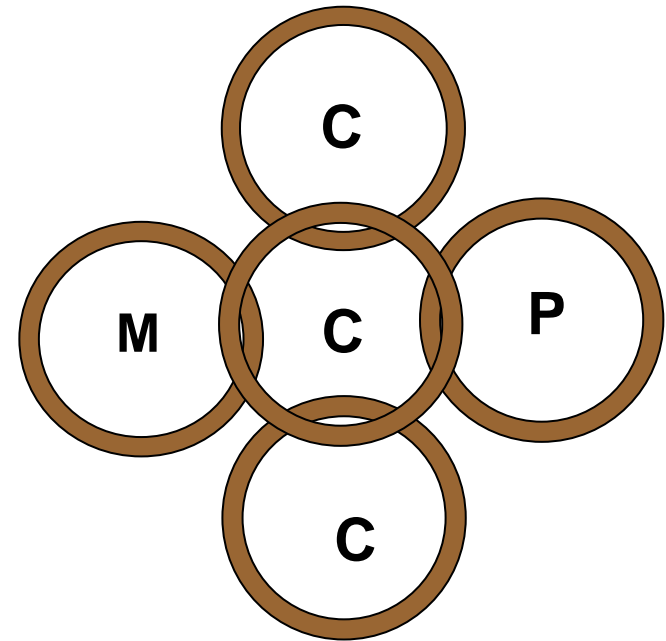
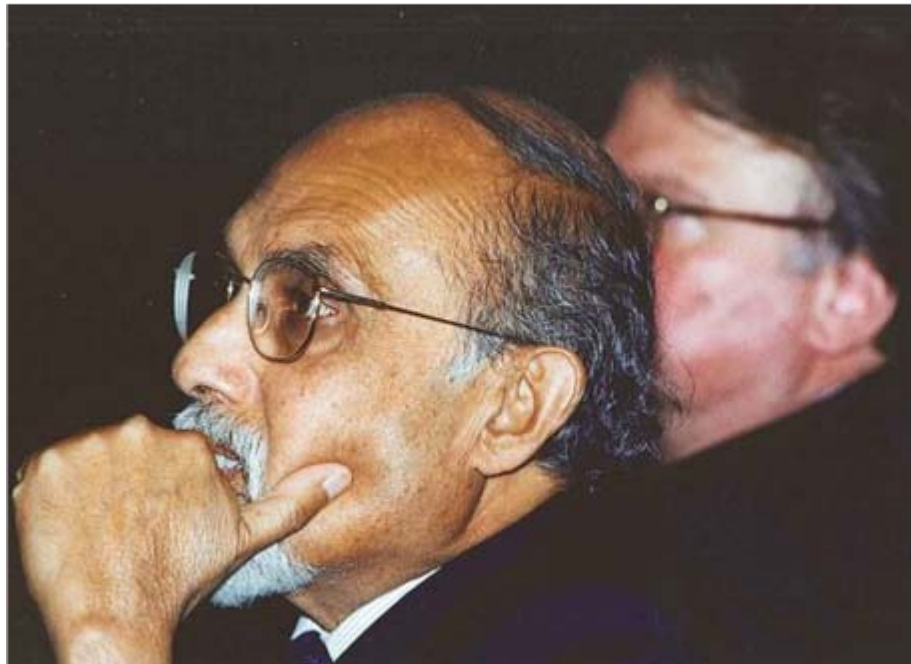


Summary

- Control is a vital dynamic field
- Networked embedded systems
- Autonomy and safety
- The educational challenge
- Recover the holistic view



Sanjoy's Half Plane



Thanks for all your contributions!
Continue to deepen insight and understanding !

