Basic control methods

Strange mixture

- Evans, W.R. (1950)
  Root-locus method
- Yakubovich, V.A. (1962)
  “LMI”
- Wonham, W.M. and Morse, A.S. (1970)
  Decoupling, pole-placement
  Geometric approach

Walter R. Evans 1920 - 1999

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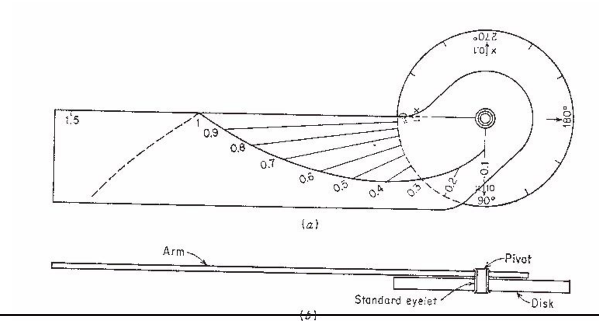
Walter R. Evans, recipient of the 1987 American Society of Mechanical Engineers Rufus Oldenburger Medal and the 1988 AACC Richard E. Bellman Control Heritage Award, passed away at the age of 79 on July 10, 1999 in Whittier, CA.

Walter Evans’ principal contribution to the field of automatic control was his invention of the Evans Root Locus Method in 1948 and his subsequent invention of the Spirule, a tool used in conjunction with the root-locus method. Because it codifies very useful frequency information about a feedback system in such intuitive and appealing graphical form, Evan’s root-locus method has enjoyed widespread use in the design of control systems and is now a standard chapter in texts on feedback control systems.

Evans received his B.S. in Electrical Engineering from Washington University in St. Louis, Missouri in 1941 and the M.S. degree in Electrical Engineering from the University of California at Los Angeles in 1951. During his lifetime, he worked as an engineer at several companies, including General Electric, Autonetics, and Ford Aeronautic Company; and he also served as an instructor at Washington University for a few years.

Root-locus

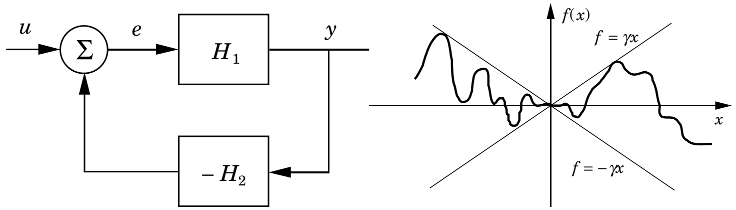
- Idea: Use the poles and zeroes of the open loop system to determine the properties of the closed loop system when ONE parameter is changing
- The membrane analogy
- The Spirule
- Quick feel for how to compensate
- Useful today?



Vladimir A. Yakubovich 1926–

Born in Novosibirsk, Russia, in 1926. Moscow University from 1946 to 1949. In 1949 he received the first prize for student scientific work and was recommended by two chairs (those of I. M. Gelfand and V. V. Nemyzki) for postgraduate education but was refused at the request of Comsomol and the Communist Party (after he had protested against discrimination of Jewish students in admittance to postgraduate studies). From 1956 to present time he has been associated with St. Petersburg University (formerly Leningrad University). Professor of Mathematics in 1963 and head of the Theoretical Cybernetics Chair in 1971.

Matrix Inequalities — The scene



- Stability of systems with sector nonlinearities, Lurie and Postnikov
- Popov, frequency domain conditions on the Nyquist curve
- Kalman, sharpens and clarifies Yakubovich' LMI condition
- The "Kalman-Yakubovich-Popov Lemma" connects two areas of control theory, frequency methods and Lyaponov methods,
- Yakubovich "Father of LMI"

Kalman-Yakubovich-Popov lemma

Given a number $\gamma \geq 0$, two n vectors b, c, and an $n \times n$ Hurwitz matrix A, if the pair $[(\; b)$ is completely controllable then q satisfying

$$A^T P + PA = -qq^T$$
$$Pb - c = \sqrt{\gamma} q$$

exists if and only if

$$\gamma + 2\mathrm{Re}[c^T(j\omega I - A)^{-1}b] \geq 0$$

for all real ω

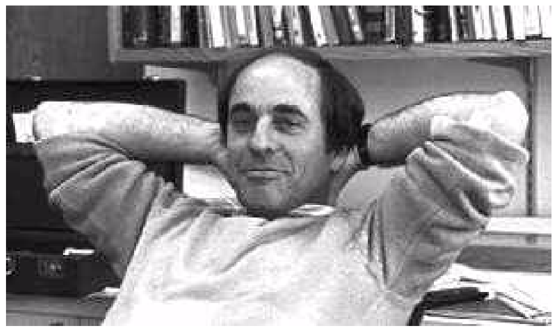
This led to the Positive real lemma, circle criterion, Zames, Positive real functions, Network theory, Adaptive control

Avoid trying to understand the paper

Decoupling and pole-placement Geometric approach

Murray Wonham, University of Toronto

Steve Morse, Yale University



Geometric approach

- Our viewpoint is that such problems are usefully treated in a geometric framework in which both definitions and results become intuitively transparent. In this way, entanglement at the outset in a thicket of algebraic calculations is avoided. (Wonham–Morse)
- Though often viewed by beginners as the system theory from an other galaxy, the geometric approach arose on Earth in the late 1960' in independent work reported in the papers Basile and Marro (1969) and Wonham and Morse (1970). (Rugh)

Decoupling

- Problem: Find feedback controller such that the inputs control the outputs independently

$$\frac{dx}{dt} = Ax + Bu$$
$$u = -Lx + Mu_r$$

- Solution in algebraic form
  Falb–Wolovich T-AC 1967
  Pole-placement in Wonham T-AC 1967
- Solution in geometric form
  Wonham–Morse (1970)
- Difficult to get into. Use an example!
- A quick glimpse can be obtained from Jack Rugh's book on linear systems, Chapter 18