A Personal Account of the Past, Present, and Future of Control Systems

1959-2009 a half century of living the experience

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Purpose of History

- Appears to be celebrating the past, but their most important function is to fix the collective identity in the present. It is a story that narrates a past to support an image of the current collective identity that confirms a certain conception of the future.

Sanjoy Mitter @ MIT/LIDS Anniversary 1998

In the beginning . . .

Transactions of the ASME–Journal of Basic Engineering, 82 (Series D): 1960, 35-45 presented at WESCON **1959**

R.E. Kalman, A New Approach to Linear Filtering and Prediction Problems (**Draper Prize 2008**)

Continuous time version with R. Bucy presented at the first ACC, MIT 1960

Four Quarters of Personal Experience

First ¼ (**1959-1969**) – Optimal Control & Aerospace Applications (**The Apollo Mission)**

The golden age – (Bryson and Ho (**1969**) – 40th publication anniversary, citation classic

Adaptive control & Identification et al

The Second Quarter (1969- early ’80s)

- Information Structure and the Witsenhausen Problem (**1968-2008**) – who knows what when.
- Games, incentives, Teams, Dynamic Teams and Differential Games (**LQG games and partially nested teams**)
- Anticipating the current interest in economics e-commerce, and computer sciences – a bit too early (**still much to do and to discover**)

The Third Quarter (‘80s-’90s)

- The Algebraic-Geometric approach to control problems – Robust, H∞ control, bilinear, and LMI control and optimization
- Manufacturing automation and Discrete Event Dynamic System (**Journal of DEDS and WODES**)

The Fourth Quarter ('90s-date)

- Merging of Operations Research, Computational Intelligence, and Control Theory
- Electric Power systems, Internet and Sensor networks, Complex systems.
- Network science (social & neural), Fuzzy Control, **Ordinal Optimization.**

Is there more? Or what next?

- A couple of basically impossible problems
- Decentralized Control
- Large Systems (state space)

On Decentralized Control

- The Witsenhausen-pb – two decisions and simplest information structure and 40 years of effort
- The problem of signaling (2003 Nobel economics prize, also 2007 Nobel prize)
- Real world complex problems of many more decisions, human emotions, and politics (**UAVs & Social Networks**)
- The No Free Lunch Theorem (**2002-04**) & Why most Things Fail (**Ormerod 2005**)

On Large Systems

- Markov chain problems involve combinatorially large state space and are seldom solved computationally
- Exponential growth is one problem that mathematics can not conquer.
- Structurally specific research necessary! (**event based MDP, Cao 2007**)

What to aim for?

- A ***"Good Enough"*** solution ***principle*** for decentralized control - **Spread sheet metaphor**
- **Reinforcement learning?**
- Specific Problems (**UAVs and power grid**)
- A ***structurally specific and useful*** class of Markov Chain Decision Problems