SCDES RETRO-PRO-SPECTIVE:
PARTHIAN SHOTS & A PARTING SHOT

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GOOD THINGS ABOUT SCDES

• Relatively **simple** to learn, do, and teach, compared to other control theories (e.g. nonlinear, on differential manifolds)

• **Expressive** of most cybernetic concepts in one way or another (feedback, stability, controllability, observability, tracking, regulation, observation uncertainty, ‘optimality’)

• **Adaptable** to cybernetic **architectures** (centralized, decentralized, distributed & networked, hierarchical, heterarchical,...)

• Naively **computable** for small systems, smart-computable (e.g. with BDDs) for large ones

• **Implementable** with industrial technologies (e.g. SFCs & PLCs)

• **Amenable** to natural **enhancements** (e.g. timed events, temporal logic, variables & guarded transitions, markovian overlays & stochastic performance, vector addition systems & links to Petri nets, ...)

FEATURES CURRENTLY LACKING IN SCDES (BUT DESIRABLE IN A CONTROL THEORY)

• ROBUSTNESS (?)
Discrete, ‘logic’-based models tend to be highly sensitive to ‘small’ modeling variations – due to modeling errors, system perturbations, or merely adjustments in ‘point of view’. This may result in ‘discontinuous behavior’.

• TRANSPARENCY (?)
Even ‘small’ DES transition structures can be hard to comprehend. How to re-structure a supervisor into a small number of simple ‘if-then’ rules expressed in natural language? Or develop standard test identifiers akin to frequency response of linear systems?

• EASE OF MODELING (?)
Even ‘simple’ logic situations can pose a challenge for DES modeling in finite automata. Better modeling tools, appealing to industrial practitioners?
BOLD SPECULATION *

* often known in English by its initials


How about catching up to the 19th – 20th cys. with an SCDES operator theory, optimistically better suited to systems that are fuzzily defined (in the every-day sense)? George Zames and Jan Willems used to stress this viewpoint, though Rudy Kalman apparently didn’t.


"When knowledge is weak and the situation is complicated, thermodynamic relations are really the most powerful."

Besides, a more “thermodynamic” approach, blended with information theory, could match the essentially cybernetic goal of enforcing the local reduction of entropy.
MORE OF THE SAME

- Combine stochastics with algebraic structure to develop Laws of Control Architecture

  Primitive (but archetypal) example:

  Tidying your desk incurs a cost, but results in improved efficiency.

  Model as a simple stochastic version of factoring a function $f = \text{findit}: X \rightarrow Y$ through its equivalence kernel as $\text{findit} = \text{easyfind} \circ \text{proj}$:

  $\text{proj}$ amounts to “tidying” $X = \text{desk}$ neat piles of items with same “use” is $n$ times more efficient than $\text{findit}$, where $n = |\ker(\text{findit})| = \# \text{ piles}$

  $\text{easyfind}$ ..... $\text{X/ker(finit)}$ ..... $\text{Y}$

  $\text{findit}$

  $\text{Y = \{possible \ "uses"\}}$
• **Categorical formalism** can provide a powerful method to manage system complexity (cf. Ehrig et al., 1997).

• Especially true for complex systems with ‘nests’ of subsystems (decentralization, distributivity), multiple layers of abstraction (hierarchy), and interaction of different dynamical ‘types’.

• Likewise, cybernetics can involve the complicated interplay of **controllability** (an issue of **subsystems**, or **monos**), **observability** (an issue of **factor systems**, or **epis**), and **hybrid dynamics** (an issue of **functors**).

• Some of that, decorated with highly intuitive **commutative diagrams**, is well known in linear systems.

• **Categorical methods** should be more widely exploited in SCDES.
VOYAGER’S PARTING SHOT OF NEPTUNE’S SATELLITE TRITON
(NASA/JPL, 1989.08.25)