Insights from Control Science for the Management of Technology

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Abstract

Control science is more than an engineering discipline. Its record of success in engineering applications—enabling the design of systems that were previously impossible, improving performance and reliability, and achieving cost-efficiencies in design and operation—can be traced to underlying principles that are universally relevant for all dynamical systems. Indeed, it is not a stretch of the imagination to claim that, "Control science is the only rigorous approach to optimized decision making in complex dynamical systems"!

Advanced control has had tremendous economic and societal impact in engineering. Facts and figures from various industry sectors (including industrial processes, commercial buildings, aircraft and spacecraft, and automotive) attest to the benefits achieved—e.g., $1 additional profit per barrel for oil refineries. Advanced control systems comprise elements such as sensors, actuators, models, estimators, and optimization, and involve distributed, decentralized, and hierarchical control architectures.

With this background, we can explore how technology management, as manifest in project management, innovation initiatives, portfolio allocation, and the like, can profit from a systems science perspective. This is not just a matter of drawing a management activity as a feedback control loop. Control science provides insights that can enlighten managerial decision makers and lead to improved decision-making performance.

About ten such "insights" have been compiled. I outline a few here:

- All advanced control relies on models of the system under control. In fact, all "informed" (i.e., nonrandom) decision making by people is also based on models—except in this case the models are in the crania of the decision makers!
- Feedback is essential for counteracting uncertainty. If we have no uncertainty about how a system—whether engineered or organizational—will perform in response to different inputs (i.e., with a perfect model and absent noise or disturbance) we can dispense with feedback and just give a "feedforward" command. For higher (e.g., faster) performance in the face of uncertainty, however, both feedforward and feedback are needed.
- Adaptation and robustness are often used interchangeably in common parlance. In control science these two terms have different meanings. Adaptation refers to the ability to change the control law (or decision-making heuristics) as the environment or the system changes,

for improved performance. Robustness refers to the ability to make decisions that will provide acceptable performance even without changing the control law, over a space of environmental changes and uncertainties. The distinction is as important for management as for control engineering.

- Easy-to-measure parameters of the system we are trying to control are not necessarily the parameters that we need to know for better control. “Estimation” algorithms allow control engineers to identify values of critical-to-know parameters (“state variables”). Again, the relevance of the concept goes beyond automation.

To fully avail of control theory for technology management, we need to model humans and their organizations quantitatively. This is much less tractable than for engineered systems and the reason why management science has not embraced control science. In the meantime, however, the insights presented are directly applicable to decision makers today and can serve as heuristic aids.

Keywords
Control theory, systems science, dynamical systems, modeling, optimization

Biography

Tariq Samad holds the Honeywell/W.R. Sweatt Chair at the Technological Leadership Institute, University of Minnesota, and is Director of Graduate Studies for the M.S. in Management of Technology program. He joined TLI in 2016 after a 30-year career with Honeywell, retiring as Corporate Fellow. At Honeywell, he led automation and control technology developments for applications in power systems, clean energy, building management, process industries, advanced manufacturing, automotive engines, and unmanned aircraft. Dr. Samad is past president of IEEE Control Systems Society and the American Automatic Control Council. He is a Fellow of IEEE and IFAC and the recipient the IEEE CSS Control Systems Technology Award, a Distinguished Member Award from IEEE CSS, and an IEEE Third Millennium Medal. He is the founding chair of the IFAC Industry Committee and serves on the IFAC Council. He holds 20 patents and has over 100 publications. His book publications include the *Encyclopedia of Systems and Control* (co-editor-in-chief, Springer, 2015). He was editor-in-chief of IEEE Press and is editor for a Wiley/IEEE Press book series, “Technology Management, Innovation, and Leadership.” Dr. Samad holds a B.S. from Yale University and M.S. and Ph.D. degrees from Carnegie Mellon University.