CIDSE Invited Talk
with John Doyle

Arizona State University

Universal laws and architectures in complex networked systems with applications to sensorimotor control

Friday, November 15, 2019
2:20PM
BYAC 110

Abstract:

Effective layered architectures such as in brains and organisms seamlessly integrate high layer goal and decision making and planning with fast lower layer sensing, reflex, and action and facilitate learning, adaptation, augmentation (tools), and teamwork, while maintaining internal homeostasis. This is all despite the severe demands such actions can put on the whole body's physiology, and despite being implemented in highly energy efficient hardware that has distributed, sparse, quantized, noisy, delayed, and saturating sensing, communications, computing, and actuation. Similar layering extends downward into the cellular level, out into ecological and social systems, and many aspects of this convergent evolution will increasingly dominate our most advanced technologies. Simple demos using audience's brains can highlight universal laws and architectures and their relevance to tech, bio, neuro, med, and social networks. This suggests conjectures about the brain but also senescence, and tradeoffs in the evolution of cancer, wound healing, degenerative diseases, auto-immunity, parasitism, and social organization, and potential animal models to explore these tradeoffs.

With this motivation, we'll sketch progress on a new unified theory of complex networks that integrates communications, control, and computation with applications to cyberphysical systems as well as neuroscience and biology. Though based on completely different constraints arising from different environments, functions, and hardware, such systems face universal tradeoffs (laws) in dimensions such as efficiency, robustness, security, speed, flexibility, and evolvability. And successful systems share remarkable universals in architecture, including layering and localization, to effectively manage these tradeoffs, as well as universal fragilities, particularly to infectious hijacking. We'll highlight diversity enabled sweet spots (DeSS) which captures perhaps the most essential feature of complex architectures. Time permitting we'll use our new theory to contrast the social architectures of EBO animals (Elephants, Bonobos, Orcas) versus humans, chimps, gorillas, lions, and other large social organisms, and discuss the inherent fragilities in the US constitution and law, as well economics and politics, and the failure of "new sciences" of complexity and networks. There are lots of online videos accessible from links on my website: http://www.cds.caltech.edu/~doyle

BIO

Jean-Lou Chameau Professor of CDS, Caltech. BS&MS EE, MIT (1977), PhD Math, UC Berkeley (1984)). Mathematical foundations for complex networks. Applications in bio, tech, med, eco, and neuro systems, and multiscale physics, integrating theory from control, computation, communication, optimization, statistics. Universal laws and architectures, robustness/efficiency and speed/accuracy tradeoffs, adaptability, evolvability, large scale systems with sparse, saturating, delayed, quantized, uncertain sensing, communications, computing, and actuation. Robust control with aerospace and industrial applications. Software such as Matlab Robust Control Toolbox and Systems Biology Markup Language (SBML). Paper prizes: IEEE Baker, Auto Control (2x), world top 10 papers in mathematics 1981-1993, AACC Schuck, ACM Sigcomm and "test of time", and Best Writing on Mathematics 2010, and many conference best papers. Individual awards: IEEE Hickernell, Centennial, and Control Systems Field Award, AACC Eckman, and UC Berkeley Friedman, plus world records and championships in various sports.

Hosted by: Yezhou Yang

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