2024 Rockwood Memorial Lecture

The Architecture of Brains

From Biology to Language, Technology, Sports, and Society

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Fung Auditorium, Powell-Focht Bioengineering Hall
University of California San Diego
Zoom: https://ucsd.zoom.us/j/2888083696

Abstract: The human brain's evolution, enabling language, technology, medicine, and society, encompasses bewilderingly diverse details and systems. Yet, all these advancements are facilitated by a shared Universal Layered Architecture (ULA). ULAs are pervasive because virtualization allows builders and users—including scientists and engineers—to grasp only fragments, while the architecture itself persists, evolves, and propagates. While ULAs usher in remarkable triumphs, they also harbor catastrophic vulnerabilities, exposing systems to pathogens, cancer, patriarchy, and the resulting pandemics and wars. ULAs thus remain perilously misunderstood. Beginning with sensorimotor control, this talk will outline ULA concepts such as Diversity-Enabled Sweet Spots (DeSS) and "constraints that deconstrain" via layers, levels, stages, the bowtie and hourglass models, and new laws on efficiency and robustness. Theory demonstrates that ULAs are necessary in overcoming biology's hardware layer constraints on sensing, communications, computing, and actions—such as sparsity, locality, saturation, and delays. This nascent theory also suggests enhancements in both understanding and design of ULAs. Examples range from cellular to societal scales, including successful animal models of social architectures from which humans could derive valuable lessons.

Biosketch: BSEE & MSEE, MIT (1977); PhD Mathematics, UC Berkeley (1984). He is most known for outstanding and forgiving students, colleagues, and family, and the shortest ever abstract in IEEE journals (and MSEE thesis at MIT). Research from 1976 was on robust control as a consultant in industry and since as an academic on mathematical foundations for a theory of architecture, with broad applications. Occasional hobbies are rigorous theories in multiscale physics, from turbulence to earthquakes. Individual awards include IEEE Power Hickernell and Control Systems Centennial and Field Awards, and world championships and records in various sports.