"Deep Learning from Nature and Machines for Engineered and Biological Materials"

Professor Subra Suresh
Nanyang Technological University, Singapore

Major advances in experimental and computational tools as well as data science and deep learning, along with the convergence of hitherto disparate disciplines at the intersections of the physical, digital and biological worlds, have provided unprecedented opportunities to design, model and characterize materials. In addition, processes, mechanisms and functions found in Nature, in concert with the latest advances in machine learning, offer unique and novel pathways to scientific discovery, mechanistic understanding, engineering design, industrial applications, and clinical practice. In this presentation, we examine our recent results from experimental, computational modeling, and data analytics of engineered and biological materials in three broad areas: materials science, plant science, and medical science. We show through examples and case studies how the appropriate combinations of experimental observations, two-dimensional and three-dimensional computational modeling and images, as well as multi-fidelity data can be combined with physics-informed neural networks and biomimetics to improve materials design, predictions of their properties and performance, and structural integrity. For biomedical applications, novel approaches that integrate microfluidic platforms with static and dynamic data and images from clinical settings are also discussed to demonstrate how deep learning approaches can offer new possibilities to improve patient outcomes in disease diagnostics, therapeutics, and treatment. Specific cases considered here are include: metallization of nanoscale diamond for tunable electronic properties; design of plant-based materials for soft robotics and sustainability; extraction of mechanical properties of materials through instrumented nanoindentation and multi-fidelity machine learning algorithms; and artificial intelligence velocimetry to probe diabetic retinopathy and blood disorders.