KTH SOLID MECHANICS KEYNOTE SEMINAR; Thursday, October 13th, 16.15; https://kth-se.zoom.us/j/64157360883

Ellen Kuhl

"Opportunities for Machine Learning in Human Health"

Ellen Kuhl is the Walter B. Reinhold Professor in the School of Engineering and Robert Bosch Chair of Mechanical Engineering at Stanford University. She received her PhD from the University of Stuttgart in 2000 and her Habilitation from the University of Kaiserslautern in 2004. Her area of expertise is Living Matter Physics, the design of theoretical and computational models to simulate and predict the behavior of living systems. Ellen has published more than 200 peer-reviewed journal articles and edited two books; she is an active reviewer for more than 50 journals at the interface of engineering and medicine and an editorial board member of seven international journals in her field. During the COVID-19 pandemic, she published a textbook on Computational Epidemiology and Data-Driven Modeling of COVID-19. Ellen is a founding member of the Living Heart Project, a translational research initiative to revolutionize cardiovascular science through realistic simulation with 400 participants from research, industry, and medicine from 24 countries. She is the current Chair of the US National Committee on Biomechanics and a Member-Elect of the World Council of Biomechanics. She is a Fellow of the American Society of Mechanical Engineers and of the American Institute for Mechanical and Biological Engineering. She received the National Science Foundation Career Award in 2010, the Humboldt Research Award in 2016, and the ASME Ted Belytschko Applied Mechanics Award in 2021. Ellen is a three-time All American triathlete, a multiple Boston, Chicago, and New York marathon runner, and a two-time Kona Ironman World Championship qualifier.

Understanding real-world dynamical phenomena remains a challenging task. In human health, as much as in many other scientific disciplines, machine learning has advanced as the go-to technology to analyze nonlinear dynamical systems, identify patterns in big data, and make decisions around them. This seminar systematically compares two families of machine learning tools and illustrates their applications in human health: neural networks and Bayesian inference. Neural networks minimize a loss function to optimize the network parameters, without any prior knowledge of the underlying physics. Physics informed neural networks expand the loss function by an additional physics term and not only interpolate the training data, but also extrapolate and predict future behavior. Bayesian inference maximizes a prior-weighted likelihood function to estimate posterior distributions of model parameters. It not only infers model parameters to fit the training data, but also provides credible intervals to quantify the quality of the model. In this talk, we illustrate the potential of neural networks, Bayesian inference, and a combination of both for dynamical systems in human health. We discuss applications to the COVID-19 pandemic, the human heart, and the aging brain with the goal to generalize physics-informed machine learning to a wide variety of nonlinear dynamical systems and open new opportunities for machine learning in the benefit of human health.