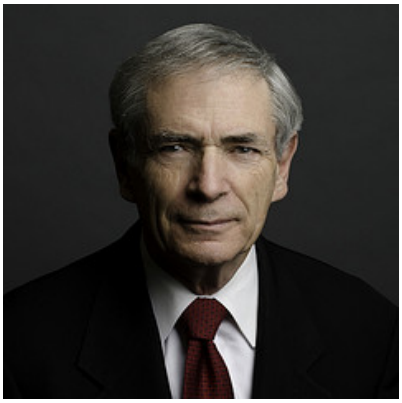
The Raymond D. Mindlin Lecture

Department of Civil Engineering & Engineering Mechanics, Columbia University
Engineering Mechanics Committee, ASCE Metropolitan Section
Engineering Mechanics Institute, ASCE

Foundations of Predictive Computational Science: Selection and Validation of Models of Complex Systems in the Presence of Uncertainty



Professor J. Tinsley Oden
Institute for Computational Engineering and Sciences
The University of Texas at Austin

March 28, 2016
2:30-3:30 pm
Davis Auditorium, 412 CEPSR

Abstract: Over the last decade or so, great interest in a subject some call predictive computational science has emerged. This has been mainly because of the dramatic advances in computers and computational science that have pushed computer modeling from a qualitative endeavor to a quantitative science in which specific predictions are sought as a basis for important, sometimes life and death, decisions: climate change, predictive medicine, design of new materials, drug design, manufacturing processes, and many other subjects. What has fueled concerns about computer predictions, and led to the study of predictive computational science, is their reliability. What factors determine the reliability of computer predictions, particularly in the presence of inevitable uncertainties? This lecture presents an introduction to mathematical, statistical, and philosophical issues underlying predictions in the presence of uncertainties -- in model selection, in model parameters, in observational data, and in the epistemology underlying the quantification of uncertainty. It is argued that a Bayesian approach provides the most logical setting for addressing these issues, complimented with tools from information theory. We describe OPAL- the Occam Plausibility Algorithm, as an adaptive approach to model selection and validation. Applications to coarse-grained models of atomistic systems, phase-field models of tumor growth, and models of gamma wave radiation are presented.

Biosketch: Dr. Oden's research focuses on contemporary topics in computational engineering and mathematics, including a posteriori error estimation, model adaptivity, multi-scale modeling, verification and validation of computer simulations, uncertainty quantification and adaptive control. Applications of current interest include molecular dynamics, continuum-quantum mechanics, modeling of semi-conductor manufacturing processes, and dynamic data-driven simulation systems for control of laser treatment of cancer. He has been on the Cockrell School of Engineering faculty (Texas, Austin) since 1973 and is also a Professor of Mathematics and a Professor of Computer Sciences. He has published more than 700 technical articles and reports, and authored or edited 50 books. Dr. Oden is a member of the National Academy of Engineering and the American Academy of Arts and Sciences and is the recipient of many national and international awards, including 10 medals, six honorary doctorates, the Chevalier de l'ordre des Palmes Académiques from the French government, and the recipient of the 2013 Honda Prize for his role in establishing the field of computational mechanics.

The Department of Civil Engineering and Engineering Mechanics established the Mindlin Lecture to honor the pioneering contributions of Prof. Raymond D. Mindlin to the field of applied mechanics. His research encompassed photoelasticity and experimental mechanics; classical three-dimensional elasticity (e.g., Mindlin's problem); generalized elastic continua (strain-gradient and couple-stress theory); frictional contact and granular media; waves and vibrations in isotropic and anisotropic plates (Mindlin's Plate Theory); wave propagation in rods and cylinders; theory of electro-elasticity and piezoelectric crystal resonators, and crystal lattice theories.
A member of the National Academy of Engineering and the National Academy of Sciences, Prof. Mindlin received the National Medal of Science for applied mechanics and mathematics in 1979. He had been awarded the Medal for Merit in 1946, by President Harry S. Truman, for his work in developing the radio proximity fuse, a detonator for weapons used in offensive warfare that was a significant factor in World War II. ASCE created the **Mindlin Medal** in 2009.