JOHNS HOPKINS
WHITING SCHOOL of ENGINEERING

Department of Civil and Systems Engineering

GRADUATE SEMINAR

Geometric learning for computational plasticity

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Geometric learning is a new field of machine learning that involves data of non-Euclidean space, such as on graphs and manifold. This presentation focuses on a newly derived framework that employs geometric learning to build interpretable macroscopic surrogate elasto-plasticity models inferred from sub-scale direction numerical simulations on granular assembles and polycrystalline materials. A graph convolutional neural network is used to deduce low-dimensional descriptors that encodes the evolutional of particle topology under path-dependent deformation and are used to replace internal variables. To circumvent the lack of interpretability of the classical black-box neural network, we introduce a higher-order supervised machine learning technique that generates multiple components of elasto-plastic models such as elasticity functional, yield function, hardening mechanisms, and plastic flow with controls on convexity and smoothness. Then, we recast the plasticity model as a Hamilton-Jacobi problem where yield function is not governed by a pre-defined hardening mechanism but may evolve in any arbitrary rules governed by the relationship between the low-dimensional descriptor interred from geometric learning and the homogenized constitutive responses. Numerical experiments reveal that the new geometric learning paradigm is capable of replicating complex elastoplastic behaviors in forward predictions.

Dr. Steve WaiChing Sun is an associate professor in the Department of Civil Engineering and Engineering Mechanics department at Columbia University. He obtained his Ph.D. in theoretical and applied mechanics from Northwestern (2011). From 2011 to 2013, He worked at the Mechanics of Materials department at Sandia (Livermore) as a postdoc and was later promoted as the senior member of technical staff before moving to Columbia in 2014. Sun's research focuses on theoretical, computational, and data-driven mechanics for porous media and geological materials. He is the recipient of the IACM John Argyris Award, the EMI Leonardo da Vinci Award, the ICE Zienkiewicz medal, NSF CAREER Award, and two Young Investigator Program Awards from the Army and Air Force.

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