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Spotting hidden weakness of constitutive laws with multi-agent deep reinforcement learning

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This talk explores the introduction of a multi-agent non-cooperative game to simultaneously calibrate, validate, and falsify constitutive laws with two competing experimentalists with the opposite task. By conceptualizing different sequential choices of experiments as a decision tree, each design of experiments become a walk in the decision tree. The deep reinforcement learning then uses Monte-Carlo tree-search to improve the estimates of policy values for each configuration of experiments used to calibrate the constitutive laws. Consequently, the competition between the protagonist and adversarial agents in the reinforcement learning framework enables us to objectively examine the experimental designs that yield the most relevant data to optimize the predictive capacity of a given constitutive model, while spotting the potential weakness of the constitutive models that may leave unreported in the literature. Numerical experiments have been conducted in both hand-crafted classical elasto-plasticity models and neural network constitutive laws. Related research directions such as model-free predictions for poromechanics problems and machine learning-enabled level set plasticity models will also be discussed.