A cooperative multi-agent game for automated physical model generations with AI-guided experimentation

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Abstract:

We introduce a meta-modeling game based on concepts from multi-graph theory to find the optimal way to generate data and write models for blind predictions of a physical process We consider an idealized situation in which the modeling process of history-dependent process can be represented by a sequence of decision making where modelers make choices to formulate a sequence of actions to generate models. While previous work on data-driven modeling often focus on completely replacing hand-crafted theory with a data-driven paradigm, our goal is to seek the best option that represents the hierarchy of material responses, i.e. the knowledge represented by a directed graph. As such, we introduce a new concept where all the modeling options can be recast as a directed multi-graph and each instant/configuration of the model can be understood as a path that links the source of the directed graph (e.g. strain history) to the sink (e.g. stress). This treatment enables us to further conceptualize the hybrid modeling process as a selection of the optimal choices in a decision tree search via deep reinforcement learning. In the case where availability of data is limited, the meta-modeling algorithm also explores the weakness links in the constitutive laws and explore the optimal set of experiments to yield the best forward predictions under a limited budget.