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An optimization-based approach for the reduction of parametrized conservation laws with discontinuities

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Partial differential equations (PDEs) are commonly used to model complex systems in applied sciences. Methods for estimating PDE parameters require repeatedly solving PDEs numerically under thousands of candidate parameter values, and thus the computational load is high and expensive. To make these problems tractable we use reduced-order models (ROMs) to reduce the computational cost of PDE solves. PDE models of fluid flow or other any advection dominated physics may produce a discontinuous solution. We will construct a bijection that aligns features in a fixed reference domain such that snapshots have jump locations at the same coordinates, independent of the parameters. We are proposing a procedure to align features in the reference domain because this will improve (increase) the N-widths decay and explicitly deal with discontinuities in the construction and definition of the ROM. To perform the alignment, we convert the discretized conservation law into a PDE-constrained optimization problem. We build a projection-based ROM in the reference domain where discontinuities are aligned. It is our goal at the offline stage during which computationally expensive training tasks compute a representative basis for the system state. Then, during the inexpensive online stage, we solve an optimization problem to compute approximate solutions for an arbitrary parameter. The solution of a new parameter would be aligned in the reference domain with the rest of the parameters encountered during the offline stage.

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