Approximation error bounds for rate-dependent Prandtl-Ishlinskii compensators

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In the past years, we observed considerable efforts to seek methods for effective compensation of hysteresis in smart actuators. Notably, rate-dependent hysteresis operators seem to offer an effective alternative for such modeling problems allowing for the characterization of complex time-dependent nonlinearities. Among the models that have been applied in hysteresis compensation, the Prandtl-Ishlinskii operator is particularly advantageous as an explicit representation of the inverse is available, even for the rate-dependent model. See [1] for the discrete case, and [2] for a more general formulation.

In this work we study error bounds of the inverse compensation when the inverse of rate-dependent Prandtl-Ishlinskii operator is applied as a feedforward compensator. More specifically, we propose the approximate inversion error relying on the inverse of a discretized rate-dependent Prandtl-Ishlinskii operator and accounting for measurement errors of the initial loading curve. It is worth recalling that the discrete rate-dependent Prandtl-Ishlinskii operator is defined as a finite linear combination of play operators with time-dependent thresholds. In practice, the number of active thresholds in the Prandtl-Ishlinskii operator can be very large, therefore requiring a non-negligible computational effort for the calculation of the explicit inverse. The question of the number of necessary thresholds for a sufficiently accurate inversion is therefore legitimate, and our numerical simulation results show that increasing the number of thresholds do not necessarily improve the algorithm's accuracy.

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References

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