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RESEARCH ARTICLE-ELECTRICAL ENGINEERING

Identification of the Continuous-Time Hammerstein Models with Sparse Measurement Data Using Improved Marine Predators Algorithm

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Abstract
In contemporary industrial applications, the complexity of systems often makes it challenging to create precise models using first-principle approaches. Consequently, researchers have turned to data-driven modeling, which offers the key advantage of developing a mathematical model of the system entirely from the input–output data captured from an actual plant. However, acquiring complete input–output data can be challenging in numerous industrial applications, where sparse measurement data frequently arise when identifying the model of these systems. Therefore, this study introduced data-driven modeling for continuous-time Hammerstein models in the presence of sparse measurement data. The analysis employed the random average marine predators algorithm (RAMPA) with a tunable step-size adaptive coefficient (CF) (RAMPA-TCF), which offers significant advantages over the conventional MPA by preventing stagnation in the local optima and enhancing the balance between the exploration and exploitation stages. Here, the structure of the unknown nonlinear subsystem was assumed to be a piecewise affine function. Meanwhile, the structure of the linear subsystem was represented by a continuous-time transfer function. Subsequently, we applied RAMPA-TCF to identify the parameters of one numerical example and a twin-rotor system (TRS) under various sparse measurement data cases. Our results demonstrated the superiority of RAMPA-TCF across several performance criteria, including the convergence curve, statistical analysis of the objective function, parameter deviation index, time- and frequency-domain responses, and Wilcoxon's rank sum test. Notably, RAMPA-TCF improved the objective function results by over 5% in the numerical example and achieved more than a 30% improvement in the TRS compared to the conventional MPA.

Keywords Marine predators algorithm · Hammerstein models · Block-oriented models · Metaheuristic algorithms · System identification

Abbreviations

ANFIS	Adaptive-network-based fuzzy inference system
CF	Step-size adaptive coefficient
CMA-ES	Covariance matrix adaptation evolution strategy
CS	Cuckoo search
DE	Differential evolution
EM	Expectation-maximization
FPA	Flower pollination algorithms
GSA	Gravitational search algorithm
GWO	Grey wolf optimizer
MIMO	Multi-input-multi-output
MOI	Missing output identification
MPA	Marine predators algorithm

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