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Automated Implementation of 1D-CAE Models and Support for Checking Consistency with Requirements

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In prior work, the authors proposed a 6-step AI-assisted specification process that outputs a model implementation specification table. This paper addresses the downstream challenge: automatically implementing 1D-CAE models from that specification and verifying correctness. The proposed pipeline receives the specification table and executes five stages: mathematical model definition, element implementation with unit verification, model integration, simulation with reporting, and HITL Validation (Fig. 1). To prevent silent hallucination, each AI agent is governed by transformation contracts — applying the Design by Contract concept— with violations detected by deterministic checks free from hallucination risk.

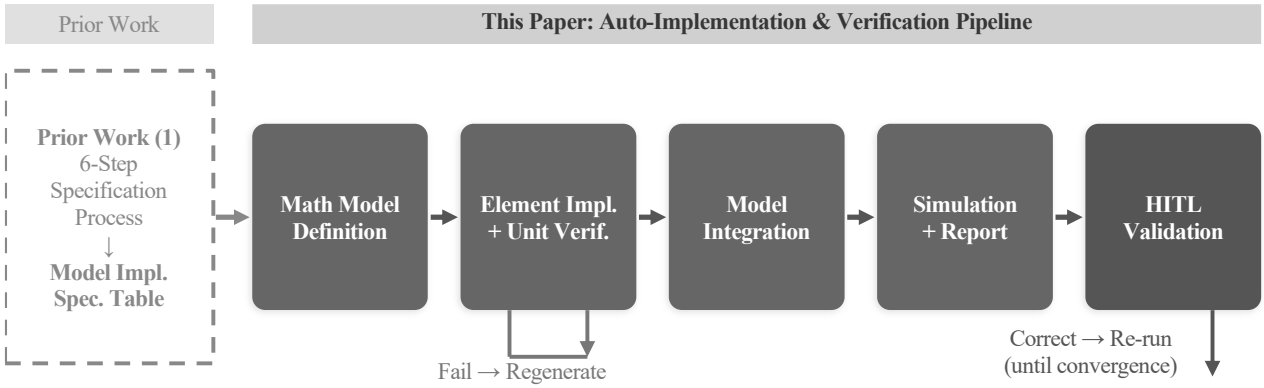

Fig.1 Connection to Prior Work and Overall Pipeline Architecture

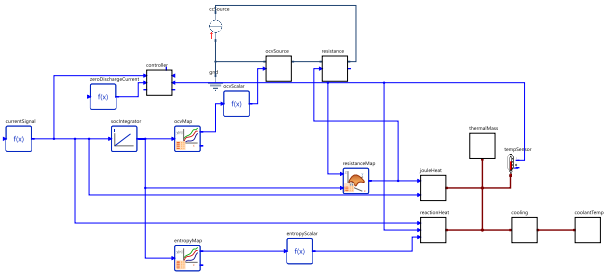

Fig.2 Automatically generated integrated model (adjust the position so as not to change the connection relationship.)

Automated verification compares specification-derived theoretical values against simulation results in two stages: steady-state check (P1) and sensitivity check (P2), providing comprehensive coverage of sign, coefficient, variable, and structural errors.

The pipeline was applied to a battery cell thermal model (50Ah Li-ion, 7 custom elements + 4 standard components). All elements were auto-generated with zero structural bugs; core thermal elements passed all health checks. Fig. 2 shows the integrated Modelica model.

HITL Validation — where AI analyzes discrepancies and generates reports for designer review — resolved parameter-level issues over 4 cycles, including internal resistance correction and entropy coefficient adjustment against literature values. Fig. 3 shows the corrected temperature profile exhibiting characteristic non-monotonic behavior caused by dOCV/dT sign reversal.

All discrepancies originated from parameter values, not AI-generated code structure. This confirms that automated verification and HITL validation address complementary quality dimensions, and their combination is essential.

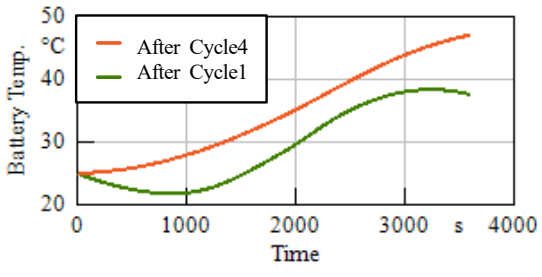

Fig.3 Simulation Results(CC Charging 50A, 3600s)