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(57) Abstract :

A multilevel layer-parallel training system (100) for transformer neural networks comprises a neural ODE transformer formulation module (110) interpreting forward propagation as ODE discretization, an MGRIT parallel computation engine (120) implementing multigrid-reduction-in-time algorithms with FCF-relaxation providing N/cf-way parallelism over the layer dimension, an encoder-decoder state management unit (130), an adaptive gradient bias correction module (140) monitoring convergence factors and controlling accuracy through automatic mode switching between parallel and serial computation, a hybrid hardware-software acceleration engine (150) with optimized kernels for heterogeneous platforms, a predictive Lipschitz stability analyzer (160) configuring buffer layers based on stability analysis, and a secure encrypted communication layer (170) enabling privacy-preserving distributed training. The system achieves parallel speedup proportional to network depth while maintaining training accuracy commensurate with serial pre-training through adaptive gradient control.

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