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(57) Abstract :

An adaptive spectral-gated residual transformation system (100) for deep neural networks is disclosed. The system includes a state matrix management unit (110) and a delta operator module (120) that applies a state-dependent rank-1 perturbation of the identity using a unit direction  $k(X)$  and scalar gate  $\beta(X)$ . A spectral gate controller (130) constrains the gate within (0, 2), enabling interpolation between identity mapping, orthogonal projection, and Householder reflection. The system also includes a value injection branch (140) and a hardware-accelerated spectral computation engine (150) with fused rank-1 update kernels (151). An adaptive self-optimizing control module (160) dynamically adjusts parameters through spectral condition monitoring, while a predictive analytics module (170) supports cross-layer parameter prediction and speculative execution. Additionally, a secure encrypted communication layer (180) and an edge-cloud synchronization engine (190) enable distributed operation. The synchronized rank-1 delta update removes existing feature components and injects new representations along a learned direction, improving validation loss, perplexity, inference latency, and power efficiency.

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