

Mitigation of Chemical Sensor Drift through Calibration Transfer in Edge AI

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Abstract:

The deployment of chemical sensor arrays in continuous industrial monitoring requires mitigating severe performance degradation caused by temporal drift, environmental variability, and device-to-device heterogeneity [1-2]. Traditional calibration transfer methods adapt chemometric models to reduce the number of expensive and impractical full recalibrations [3]. Recently, modern Edge AI architectures introduce new dimensions for long-term applications since running calibration models on local hardware devices reduce network load, privacy concerns, and latency. On the other hand, models may run on strict resource budget in terms of computational throughput and power [4-5]. This work shows calibration sustainability principles with resource-aware neural network scaling. Five Temporal Convolutional Networks (TCNs) are evaluated under strict parameter budgets (8K to unconstrained) and benchmarked across eleven multi-domain datasets and an 11-month industrial electronic nose dataset undergoing real-world seasonal drift. Results show that macro-F1 performance scales with parameter capacity rather than architectural configuration itself. Although seasonal variations inevitably trigger progressive degradation, mid-sized models optimize the trade-off between accuracy and hardware constraints, while lighter models achieve smaller latencies. This framework bridges the gap between algorithmic model adaptation and edge deployment, establishing sustainable strategies that reduce recalibration frequency in long-term autonomous sensing.

Keywords:

Calibration transfer, Electronic nose, Edge AI, Sensor drift, Deep Learning

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