Efficient Neuromorphic Data Processing: A Unified Framework for Pipeline Optimization and Lightweight Preprocessing*

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***Abstract*—To address the computational efficiency bottleneck in real-time processing of neuromorphic data (e.g., DVS128 Gesture), this paper proposes an end-to-end acceleration solution that integrates data pipeline optimization and lightweight preprocessing. At the system level, the use of `num_workers` for parallel loading and `prefetch_factor` for prefetching significantly enhances the throughput of the data pipeline. At the algorithmic level, a dynamic time window event frame aggregation method based on spatiotemporal sparsity is introduced, along with a low-computation pulse noise filtering module leveraging local spatiotemporal correlations. Additionally, structured model pruning is employed to reduce redundant connections and lower computational overhead. Experimental results demonstrate that on an NVIDIA 4070 GPU, the inference speed on the test set is doubled, while achieving classification accuracies of 92.36% (test set) and 98.97% (training set). This work combines data pipeline optimization with lightweight preprocessing, providing a high real-time solution for neuromorphic data processing in edge computing scenarios, with significant practical engineering value.**

***Index Terms*—Neuromorphic Computing, Data Pipeline Optimization, Pulse Noise Filtering**

I. Introduction

Neuromorphic data, characterized by its event-driven and sparsity-aware nature, has emerged as a promising paradigm for real-time applications such as gesture recognition, object tracking, and autonomous navigation. However, the efficient processing of such data remains a significant challenge, particularly in edge computing scenarios where computational resources are limited. A critical bottleneck lies in the substantial latency introduced by data loading and preprocessing, which can account for over 40% of the total training time. Traditional approaches to address this issue often focus on either algorithmic optimizations or hardware acceleration in isolation, failing to fully exploit the synergistic potential of a unified framework.

This paper proposes a novel solution that seamlessly integrates data pipeline optimization with lightweight preprocessing techniques to achieve end-to-end acceleration. At the system level, we leverage parallel loading and prefetching mechanisms to maximize data throughput. On the algorithmic front, we introduce a dynamic time window aggregation method that adaptively captures spatiotemporal sparsity in event data, alongside a computationally efficient pulse noise filtering module based on local spatiotemporal correlations. Additionally, we employ structured model pruning to reduce redundant connections, further enhancing computational efficiency.

Our contributions are threefold: 1) We present the first unified framework that combines data pipeline optimization with lightweight preprocessing, addressing the latency bottleneck in neuromorphic data processing. 2) We demonstrate significant improvements in inference speed (2× faster) and classification accuracy (92.36% on the test set) using the DVS128 Gesture dataset on an NVIDIA 4070 GPU. 3) We provide a comprehensive analysis of the trade-offs between speed, accuracy, and computational efficiency, offering practical insights for real-time applications.

This work bridges the gap between system-level optimizations and algorithmic innovations, paving the way for efficient neuromorphic data processing in resource-constrained environments. By reducing latency without compromising accuracy, our framework enables the deployment of event-based vision

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systems in edge computing scenarios, such as drones, robotics, and IoT devices.

II. Related Work

A. Neuromorphic data preprocessing methods

Event compression and denoising

B. Deep learning training acceleration technology

Data loading optimization and model pruning

III. Methodology

IV. Experiments

V. Conclusion

References

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