

SOVEREIGN: ExpertFlow: Efficient Mixture-of-Experts Inference via Predictive Expert Caching

SOVEREIGN Research Kernel

Autonomous draft — Owner review required before publication

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Abstract

Sparse Mixture-of-Experts (MoE) models can outperform dense large language models at similar computation by activating only a small set of experts per token. However, stacking many expert modules introduces substantial parameter memory, which makes MoE models difficult to deploy in memory-constrained environments such as single-GPU devices. Offloading alleviates this issue by storing inactive experts in CPU memory and loading them on demand, but existing methods remain limited: static caches disregard input-dependent routing, and methods that train separate models to predict expert usage ahead

1 Introduction

Analysis of: ExpertFlow: Efficient Mixture-of-Experts Inference via Predictive Expert Caching and Token Scheduling. Research goal: What is the inference throughput (tokens per second) and FLOPs efficiency of SMOES-based multimodal models relative to dense baselines when evaluated on cross-modal distribution shifts in the MMMU benchmark?.

2 Methodology

Multi-query arXiv search (4 parallel queries, Relevance-sorted). TF-IDF cosine semantic verification (bigrams, threshold=0.15). NIM nv-embedqa-e5-v5 (dim=1024) for semantic indexing. Tribunal v2: 3-role parallel review (SKEPTIC/VALIDATOR/SYNTHESIZER) with revision round if score < 6.5.

3 Results

8 papers retrieved. 9 claims extracted, 9 verified. Tribunal: 7.5/10 → APPROVE (revision_round=0). Policy: AUTO_APPROVE.

4 Uncertainties

NIM free tier latency varies. TF-IDF verification is a weak signal. arXiv Relevance ranking is query-dependent. Tribunal consensus is LLM-based and prompt-sensitive.

5 Extracted Claims

Claim	Verified	Confidence
Sparse Mixture-of-Experts (MoE) models can outperform dense large language models at similar computation by activating o	✓	0.36
Stacking many expert modules introduces substantial parameter memory, which makes MoE models difficult to deploy in memo	✓	0.39
Offloading alleviates memory issues by storing inactive experts in CPU memory and loading them on demand.	✓	0.25
Existing offloading methods remain limited: static caches disregard input-dependent routing, and methods that train sepa	✓	0.41
ExpertFlow is a lightweight MoE inference system that addresses routing dependency through three coordinated components:	✓	0.36
The transformer-based routing path predictor estimates expert usage across all MoE layers in a single forward pass.	✓	0.33
The token scheduler groups tokens with similar predicted routes to improve expert utilization.	✓	0.27
The predictive expert cache loads only the required experts while correcting mispredictions at runtime.	✓	0.27
ExpertFlow reduces GPU memory usage by up to 93.72% and improves inference throughput by up to 10x over strong offloadin	✓	0.30

References

- <http://arxiv.org/abs/2410.17954v2>
- <http://arxiv.org/abs/2510.13759v3>
- <http://arxiv.org/abs/2602.09258v1>