

# SOVEREIGN: SMOES: Soft Modality-Guided Expert Specialization in MoE-VLMs

SOVEREIGN Research Kernel

Autonomous draft — Owner review required before publication

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## Abstract

Mixture-of-Experts (MoE) has become a prevalent backbone for large vision-language models (VLMs), yet how modality-specific signals should guide expert routing remains under-explored. Existing routing strategies are either hand-crafted or modality-agnostic, relying on idealized priors that ignore the layer-dependent modality fusion patterns in MoE-VLMs and provide little guidance for expert specialization. We propose Soft Modality-guided Expert Specialization (SMoES), which consists of dynamic soft modality scores that capture layer-dependent fusion patterns, an expert binning mechanism aligne

## 1 Introduction

Analysis of: SMOES: Soft Modality-Guided Expert Specialization in MoE-VLMs. Research goal: Does the soft modality-guided routing mechanism in SMOES MoE-VLMs improve robustness to distribution shift on the MMMU benchmark compared to dense baselines, and how does this robustness scale from 7B to 34B total parameters?.

## 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

12 papers retrieved. 5 claims extracted, 4 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
SMoES achieves a 0.9% average gain on multimodal tasks and a 4.2% average gain on language-only tasks across four MoE-based	✓	0.21
SMoES reduces EP communication overhead by 56.1%.	×	0.12
SMoES achieves a 12.3% throughput improvement under realistic deployment.	✓	0.17
Existing routing strategies in MoE-VLMs are either hand-crafted or modality-agnostic.	✓	0.24
SMoES consists of dynamic soft modality scores, an expert binning mechanism, and inter-bin mutual information regularization	✓	0.37

## References

- <http://arxiv.org/abs/2410.07167v2>
- <http://arxiv.org/abs/2603.11114v1>
- <http://arxiv.org/abs/2604.23996v1>