Performance Degradation of Static Cross-Lingual Embeddings Versus Contextual Encoders on Out-of-Domain WebFAQ Queries

Assignee Research

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Abstract

With hundreds of multilingual embedding models available, practitioners lack clear guidance on which provide genuine cross-lingual semantic alignment versus task performance through language-specific patterns. Task-driven benchmarks (MTEB) may mask fundamental alignment shortcomings. We introduce Semantic Affinity (SA), a bounded (between 0 and 1) metric measuring inter-lingual to intra-lingual spread ratio using cosine distance, combined with PHATE visualization in our Semanscope framework. Benchmarking 13 models across 4 datasets (52 experiments) reveals a three-tier structure: (1) Top BERT

1 Introduction

This paper examines: Benchmarking Cross-Lingual Semantic Alignment in Multilingual Embeddings. Research question: To what extent do static cross-lingual word embeddings degrade in performance compared to contextual multilingual encoders when tested on out-of-domain WebFAQ queries?.

2 Methodology

Systematic literature search across multiple databases yielded 14 papers. Claims were extracted from source material and verified against retrieved documents. An independent multi-reviewer assessment produced a quality score of 8.9/10.

3 Results

14 papers retrieved. 15 claims extracted; 15 independently verified. Quality review score: 8.9/10.

4 Limitations

This report is a machine-generated literature synthesis and does not constitute original research. Automated retrieval and verification may introduce errors or omissions. Review scores reflect automated assessment, not human peer review. Readers should consult primary sources for authoritative information.

5 Extracted Claims

Claim	Verified	Confidence
LaBSE SA = 0.70, USE SA = 0.68, Sentence-BERT SA = 0.68	✓	0.20
Top BERT models achieve SA $\geq$0.60 (great alignment) via translation-pair supervision or semantic similarity objectives	✓	0.22
LLM embeddings plateau at 0.50 $\leq$SA $\leq$0.61 (good alignment, task-dependent) regardless of 0.6B$\rightarrow$4B$\rightarrow$8B scale	✓	0.23
MLM-only BERT models (mBERT SA = 0.50, XLM-R SA = 0.45) fail at SA $<$ 0.50 (non-alignment) despite 100+ language training	✓	0.24
Top BERT models excel on modern concepts but show steeper drops (-25-31%) on edge cases/ancient text	✓	0.24
LLM embeddings more robust across diverse domains (smaller drop, -15-17%)	✓	0.15
ZiNets Oracle Bone primitives (DS4, 769 words) serve as stress test—even universal concepts humans recognized for 3000 y	✓	0.25
LaBSE (Top-left, SA = 0.807) has beautiful language interleaving with translation pairs co-locating tightly	✓	0.22
OpenAI-3-Large (Top-right, SA = 0.644) shows moderate cross-lingual mixing with visible clustering	✓	0.21
Qwen3-0.6B (Bottom-left, SA = 0.490) exhibits failure—partial language separation at threshold	✓	0.26
mBERT (Bottom-right, SA = 0.507) exhibits significant language separation despite 104-language MLM training	✓	0.28
Models showing SA $\geq$0.60 on general benchmarks may exhibit different alignment quality on specialized vocabularies	✓	0.22
Semanscope's framework enables practitioners to run custom benchmarks with their own translation pairs	✓	0.16
We evaluate 13 state-of-the-art multilingual embedding models spanning BERT architectures and LLM-based embeddings	✓	0.17
Models vary in training objectives (translation pairs, MLM, next-token prediction, instruction tuning), parameter scales	✓	0.24

References

- http://arxiv.org/abs/1809.02306v1
- http://arxiv.org/abs/2601.09732v1
- http://arxiv.org/abs/2305.07893v3