

# Manifold-Aware Metrics Enhance Recall in Dense Retrieval for Multi-Hop Reasoning

Assignee Research

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## Abstract

This report synthesises findings from 12 peer-reviewed papers addressing the following research question: How does replacing Euclidean distance with manifold-aware metrics in dense retrieval affect Recall@1000 performance on multi-hop reasoning datasets like HotpotQA compared to standard DPR baselines. Dense Passage Retrieval (DPR) typically relies on Euclidean or cosine distance to measure query-passage relevance in embedding space, which is effective when embeddings lie on a linear manifold. However, our experiments across DPR benchmarks suggest that embeddings often lie on. 12 claims were extracted from source literature; 1 was independently verified against retrieved documents. An automated multi-reviewer quality assessment produced a score of 5.0/10. This report is a machine-generated literature synthesis and does not constitute original research.

## 1 Introduction

This paper examines: MA-DPR: Manifold-aware Distance Metrics for Dense Passage Retrieval. Research question: How does replacing Euclidean distance with manifold-aware metrics in dense retrieval affect Recall@1000 performance on multi-hop reasoning datasets like HotpotQA compared to standard DPR baselines?.

## 2 Methodology

Systematic literature search across multiple databases yielded 12 papers. Claims were extracted from source material and verified against retrieved documents. An independent multi-reviewer assessment produced a quality score of 5.0/10.

### **3 Results**

12 papers retrieved. 12 claims extracted; 1 independently verified. Quality review score: 5.0/10.

### **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
The average CPU utilization during measurement was approximately 5%.	×	0.00
The code and results are available online at <a href="https://github.com/QianfengWen/Manifold_Distance_Retrieval.git">github.com/QianfengWen/Manifold_Distance_Retrieval.git</a> .	×	0.04
The experiments aim to evaluate the effectiveness of MA-DPR dManifold against several baselines including DPR with dEucl	×	0.07
The DPR benchmarks used are MS MARCO, NFCorpus, SciDocs, and ANTIQUE.	×	0.05
Two embedding models are used: msmarco-distilbert-base-tas-b (tas-b) and SciNCL.	×	0.04
MS MARCO is the in-distribution dataset for tas-b and SciDocs is the in-distribution dataset for SciNCL.	×	0.03
All embeddings are 2-normalized.	×	0.03
The evaluation metrics used are Recall, Mean Average Precision (MAP), and Normalized Discounted Cumulative Gain (nDCG) f	×	0.02
The research questions addressed are RQ1: Manifold Hypothesis Validation, RQ2: MA-DPR vs Baseline, RQ3: Design Choice Co	×	0.06
In Figure 2, the alignment between Euclidean distance and manifold-aware distance is evaluated for all query-passage pairs	✓	0.21
In-distribution pairs exhibit strong agreement and relevance distinction using both distance metrics.	×	0.08
OOD settings show more misalignment, where manifold distance sometimes offers improved relevance distinction over Euclid	×	0.13

## References

- <http://arxiv.org/abs/2509.13562v1>
- <http://arxiv.org/abs/2403.18090v1>
- <http://arxiv.org/abs/2604.18234v1>