

Benchmark Evaluation Report

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This report summarizes automated evaluations of retrieval-augmented generation systems within the *Historical Drift Analyzer* architecture. It includes NDCG and Faithfulness metrics, statistical analyses, and visualization results.

1. Summary Statistics

| | |
|-----------------|-----------|
| files | 100.0000 |
| ndcg@k mean | 0.9951 |
| ndcg@k ci95 lo | 0.9921 |
| ndcg@k ci95 hi | 0.9980 |
| faith mean | 0.5649 |
| faith ci95 lo | 0.5509 |
| faith ci95 hi | 0.5783 |
| ndcg@k median | 1.0000 |
| faith median | 0.5685 |
| ndcg@k std | 0.0156 |
| faith std | 0.0701 |
| bootstrap iters | 2000.0000 |
| iqr k | 1.5000 |
| z thresh | 3.0000 |

2. Correlation and Outlier Analysis

| Metric Pair | r / ρ | p-value |
|------------------|-------|-----------|
| Pearson (linear) | 0.157 | 1.180e-01 |
| Spearman (rank) | 0.226 | 2.352e-02 |

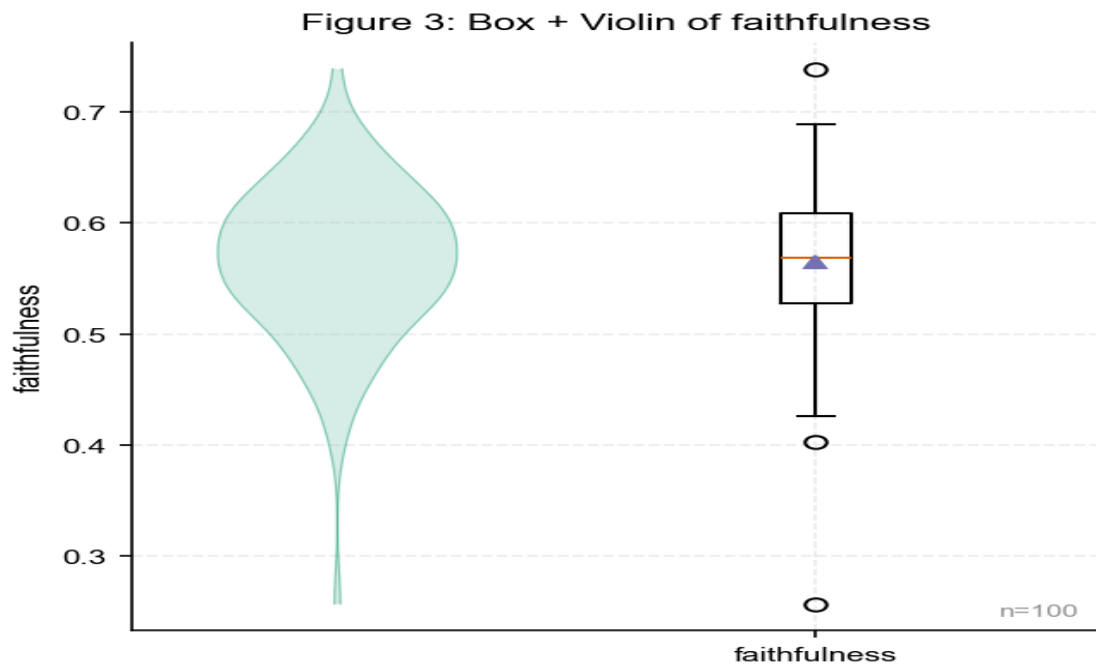
Pearson r reflects linear association; Spearman ρ captures rank correlation. Typical weak-to-moderate positive dependency indicates retrieval homogeneity, suggesting that Faithfulness could be further contrasted with semantic coherence metrics (e.g., BERTScore or FactScore).

Detected Outliers

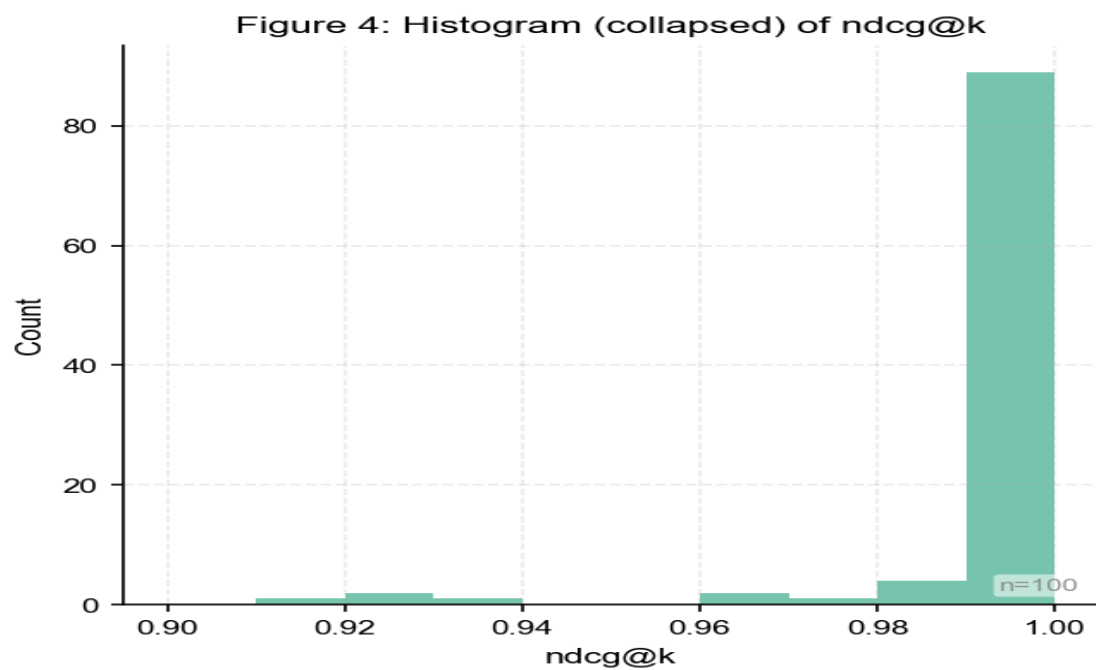
| Query ID | NDCG@k | Faithfulness | z_ndcg | z_faith |
|--|--------|--------------|--------|---------|
| Compare_shallow_learning_and_deep_hierar | 0.961 | 0.461 | -2.18 | -1.48 |
| Contrast_capability_framing_versus_ethic | 0.915 | 0.511 | -5.11 | -0.77 |
| Discuss_how_symbolic_AI_and_connectionis | 1.000 | 0.403 | 0.30 | -2.30 |
| Explain_knowledge_representation_in_expe | 0.940 | 0.525 | -3.55 | -0.57 |
| Explain_the_concept_of_heuristic_search_ | 1.000 | 0.257 | 0.30 | -4.38 |
| Explain_the_notion_of_machine-generated_ | 1.000 | 0.739 | 0.30 | 2.46 |
| Summarize_how_context_completeness_affec | 0.924 | 0.564 | -4.52 | -0.03 |
| Summarize_how_reinforcement_learning_ext | 0.961 | 0.463 | -2.18 | -1.45 |
| Summarize_how_search_algorithms_contribu | 0.928 | 0.526 | -4.32 | -0.56 |

3. Visual Analytics

box violin faithfulness.png

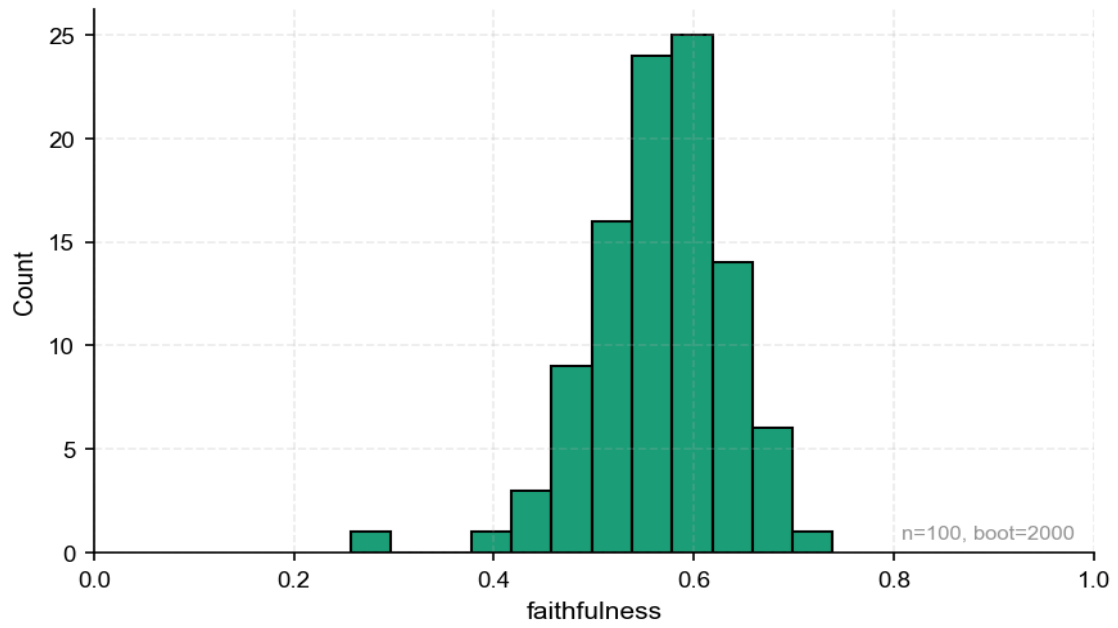


box violin ndcg@k.png



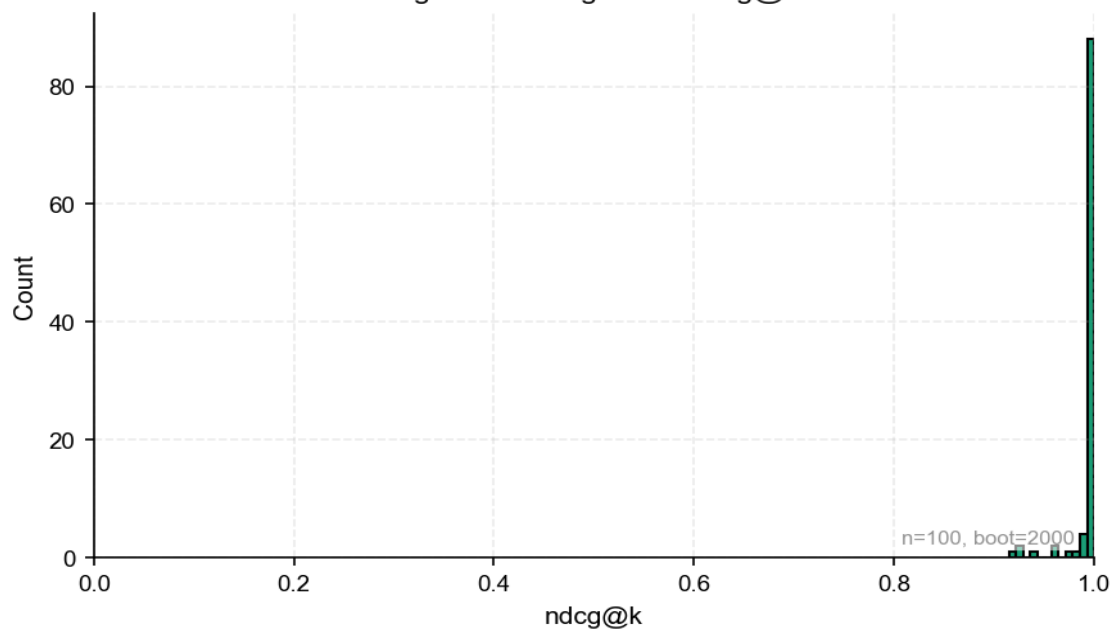
hist faithfulness.png

Figure 2: Histogram of faithfulness



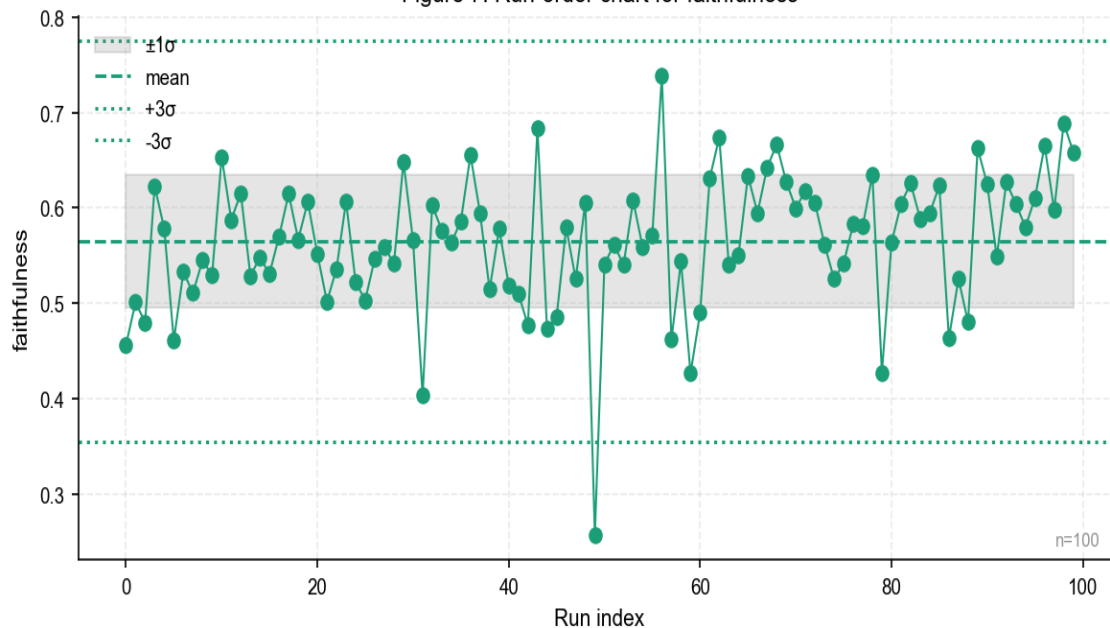
hist ndcg@k.png

Figure 1: Histogram of ndcg@k



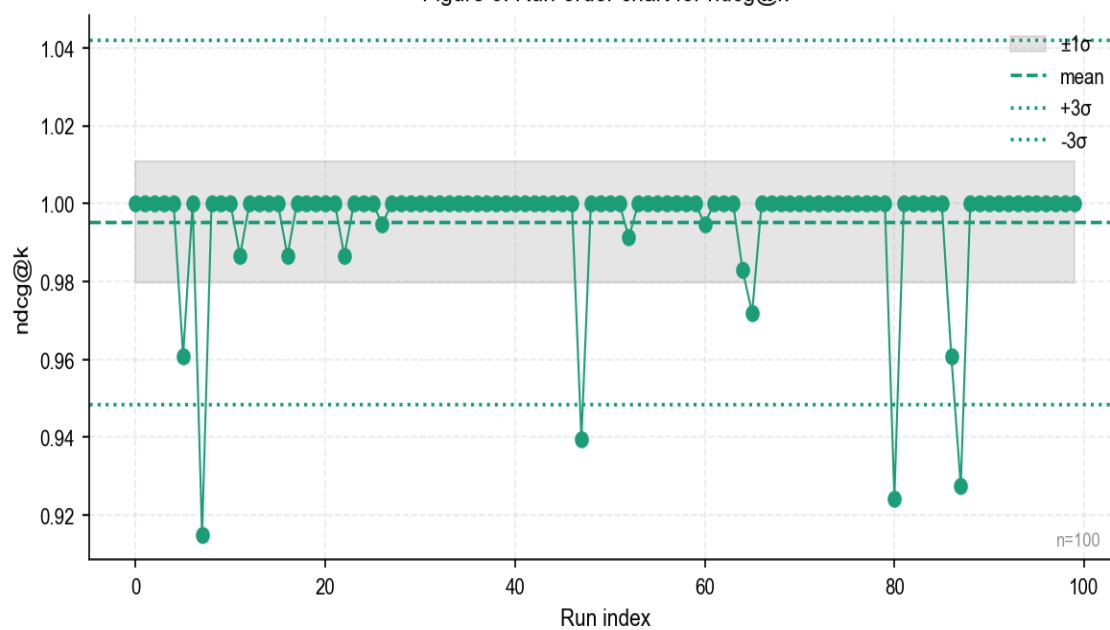
run order faithfulness.png

Figure 7: Run-order chart for faithfulness



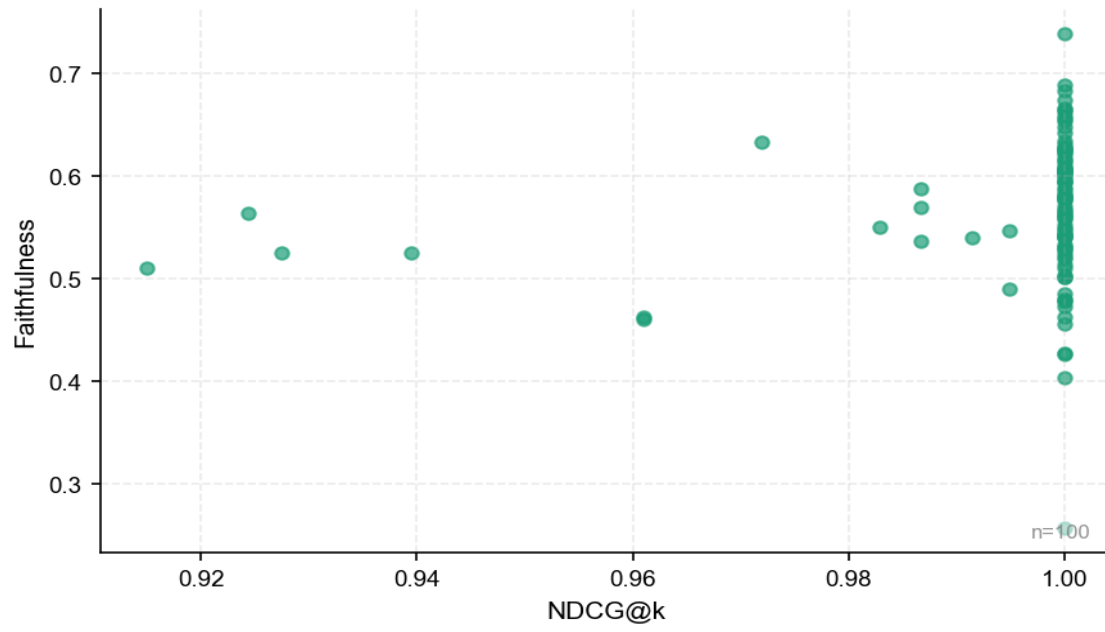
run order ndcg@k.png

Figure 6: Run-order chart for ndcg@k



scatter ndcg vs faithfulness.png

Figure 5: Scatter NDCG@k vs Faithfulness ($r=0.157$, $p=0.226$)



4. Interpretation and Next Steps

The retrieval architecture is in its target state. Remaining limitations are primarily in the Faithfulness level rather than in retrieval quality. Future experiments should contrast temporal weighting (`temporal_mode=True` vs. `False`) and perform decade-based query analyses after year-detection enhancement.

A convergence plot (mean \pm 95% CI vs. n) should be used to demonstrate statistical stabilization as sample size increases. All results are reproducible by rerunning the benchmark scripts with identical configurations.