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A Comparative Analysis of Retrievability and PageRank Measures

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Overview

- Introduction
- Brief summary of Pagerank and Retrievability
- Measures used to quantify associated bias
- Experiment and Dataset
- Results
- Conclusion

Introduction

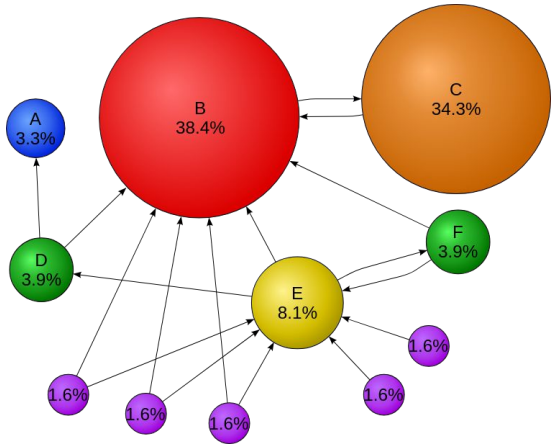
- Accessibility - ease of locating content within collection
- Critical role of document accessibility in IR.
- Two primary avenues:
  - Retrieval models (retrievability scores) and
  - Navigability metrics (PageRank, Hub, Authority).
- Retrievability scores focus on efficient document retrieval within a collection.
- Navigability metrics emphasize the web of connections between documents.

PageRank - A measure of Importance

- PageRank is a link analysis algorithm.
- Assigns a numerical weighting to each page based on its importance within a set of hyperlinked documents.
- Considers links as 'votes' by all other pages on the Web.
- Used as a ranking criterion in search engines, with higher PageRank values indicating greater importance.

PageRank - A measure of importance

$$PR(A) = (1 - \lambda) + \lambda \cdot \sum_{i=1}^{n} \frac{PR(T_i)}{C(T_i)}$$



- PageRank works by counting the number and quality of links to a page to determine a rough estimate of how important the website is.
- The underlying assumption is that more important websites are likely to receive more links from other websites.

Retrievability - A Measure of Accessibility

- Retrievability measures the ease of retrieving a document in an IR system.
- Introduced by Azzopardi and Vinay, quantified through the retrievability score r(d).
- Retrievability score is computed using formula

$$r(d) = \sum_{q \in Q} o_q \cdot f(k_{dq}, c)$$

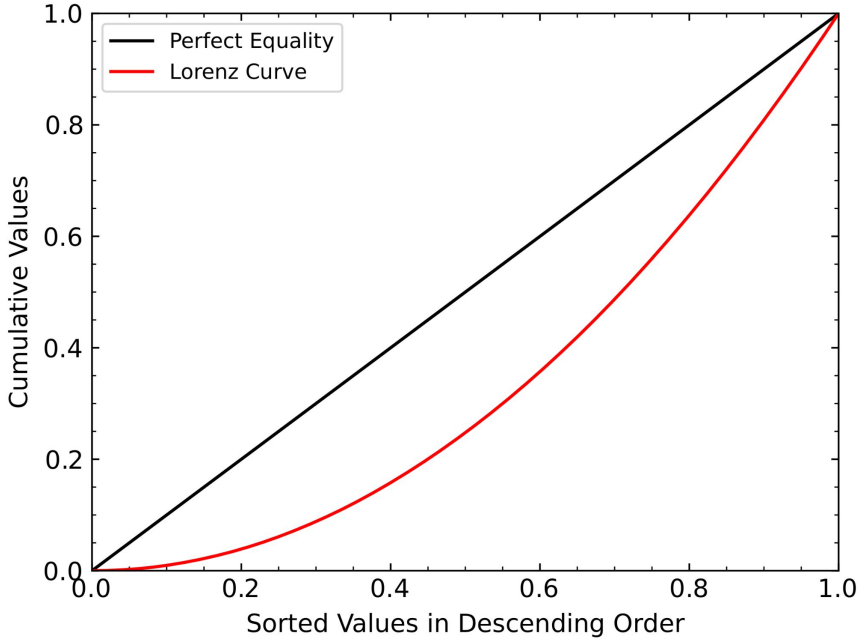
Retrievability - A Measure of Accessibility

- Retrieval relies on a set of queries Q with opportunity weights o_q.
- Query set theoretically encompasses all conceivable queries answerable by the collection D.
- k_dq denotes the retrieval rank of document d for a particular query q.
- Utility function f(k_dq, c) indicates the retrievability of document d within a specified rank cutoff c.

$$r(d) = \sum_{q \in Q} o_q \cdot f(k_{dq}, c)$$

Lorenz Curve

- Cumulative score distribution of documents sorted by their retrievability scores in ascending order
- analyze the degree of inequality or bias within the retrieval system.



Linear Lorenz Curve:
- Retrievability scores evenly distributed.
- Indicates a balanced system without significant bias.

Skewed Curve:
- Uneven distribution of retrievability scores.
- Signifies a higher level of inequality or bias within the system.

Gini coefficient - amount of biasness

- To summarize the amount of bias in the Lorenz Curve, the Gini coefficient G is commonly employed

$$G = \frac{\sum_{i=1}^{N} (2i - N - 1) \cdot r(d_i)}{N \sum_{j=1}^{N} r(d_j)}$$

- Expressed as a number between 0 and 1
  - 0 represent perfect equality
  - 1 represents perfect inequality

N represents total number of documents in the collection

"Are there correlations between the PageRank scores and Retrievability scores of the collection documents? Is there a rank correlation between these two metrics?"

Datasets

Dataset	# documents	Collection Type
WT10G	1,692,096	Web
Wikipedia	6,584,626	Wiki

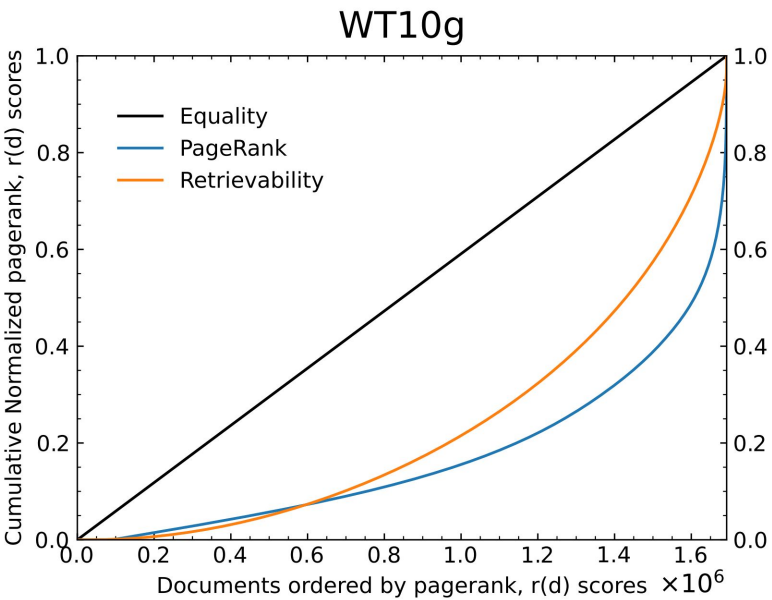
English Wikipedia article dump from February 2023

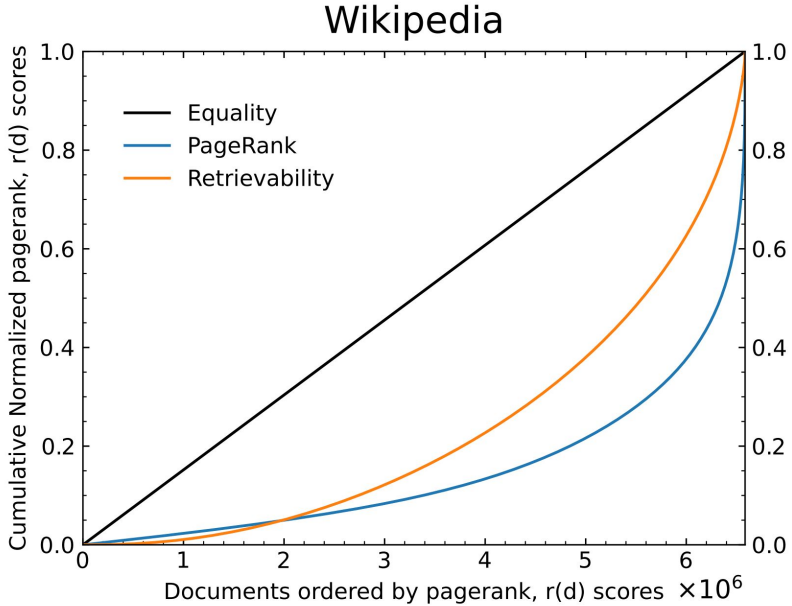
WT10g: TREC Web Corpus

1. https://dumps.wikimedia.org/enwiki

Lorenz curve

Examining the distribution disparities within the retrievability scores and PageRank





Experiment Results

Gini Coefficient quantifies the disparities between retrievability and pagerank scores

	Gini Coefficient	
	Retrievability	**PageRank**
WT10g	0.5371	0.6618
Wikipedia	0.5380	0.7050

	Kendall's τ	**Spearman's ρ**	**RBO**
WT10g	0.0487	0.0730	0.5173
Wikipedia	0.1532	0.2247	0.5633

A weak correlation exists between Ranks of documents based on scores of PageRank and Retrievability

Conclusion

- Document Accessibility:
  - Retrieval models and navigation assess document accessibility.
  - Retrievability scores measure retrieval ease; navigation metrics indicate discoverability via document links.
- Retrievability vs. PageRank:
  - Study on WT10g and Wikipedia datasets.
  - WT10g shows minimal correlation; Wikipedia demonstrates better agreement due to size, interconnectivity and diversity.
- Correlation Analysis:
  - Used Kendall's and Spearman's coefficients.
  - More correlation in the larger, linked Wikipedia dataset.
- Ranked Biased Overlap Measurements
  - Top ranked documents are substantially similar for both datasets.

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Thank You!