Applying Science Models for Re-Ranking in IR

Introducing bibliometrically enhanced metadata to IR

By Andreas Kruff, Anh Huy Matthias Tran

Agenda

1. Introduction

Project Motivation

Dissertation: **'Re-Ranking auf Basis von Brafordizing für die verteilte Suche in Digitalen Bibliotheken'** *(Mayr, 2009)*

Introduction of new metrics for bibliometrically enhanced Information Retrieval (BIR) in the context of Re-Ranking.

Application Case

- Recent data sets: ***TREC-COVID***
- In combination with *Graph Construction & Network Analysis*

Project Motivation

Papers: **'Science models as value-added services for scholarly information systems'** *(Mutschke, 2011)*

Introduction of scholarly Information Retrieval (IR) as a further developed models for improving retrieval quality, involving features such as Bradford law of Information and co-authorship networks.

Application Case

- ❖ Recent data sets: **TREC-COVID**
- ❖ In combination with *Graph Construction & Network Analysis*

Ranking	Document	Score	Journal	coreness
1	Doc 10	15.4646	bioRxiv	0.35
2	Doc 15	14.3549	Emerg Infect Dis	0.24
3	Doc 101	14.3542	Journal of virology	0.12
[...]	[...]	[...]	[...]	[...]
998	Doc 17	1.636	J Biomed Sci	0.01
999	Doc 4	0.002	Emerg Infect Dis	0.12
1000	Doc 90	0.000	bioRxiv	0.35

Further Motivations

As mentioned in the lectures concerning topics such as

- **Network Analysis**
  Centrality, Betweenness
- **Power Law's**
  Lotka's Law, Bradford law and Zipf's law
- **Re-Ranking**
  Based on Bibliometrics and authorships

Further Motivations

As mentioned in the lectures concerning topics such as

Stratagems *(as defined by Marcia Bates)*

- **Citation Search**

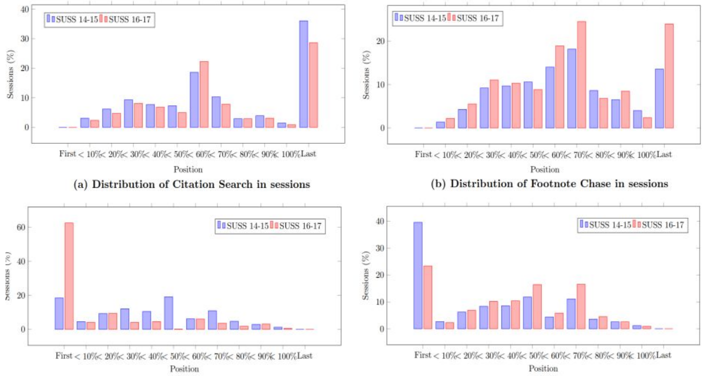
  Usage of provided citation connections

- **Author Search**

  Usage of provided author connections

- **Journal Run**

  Usage of given journal connections



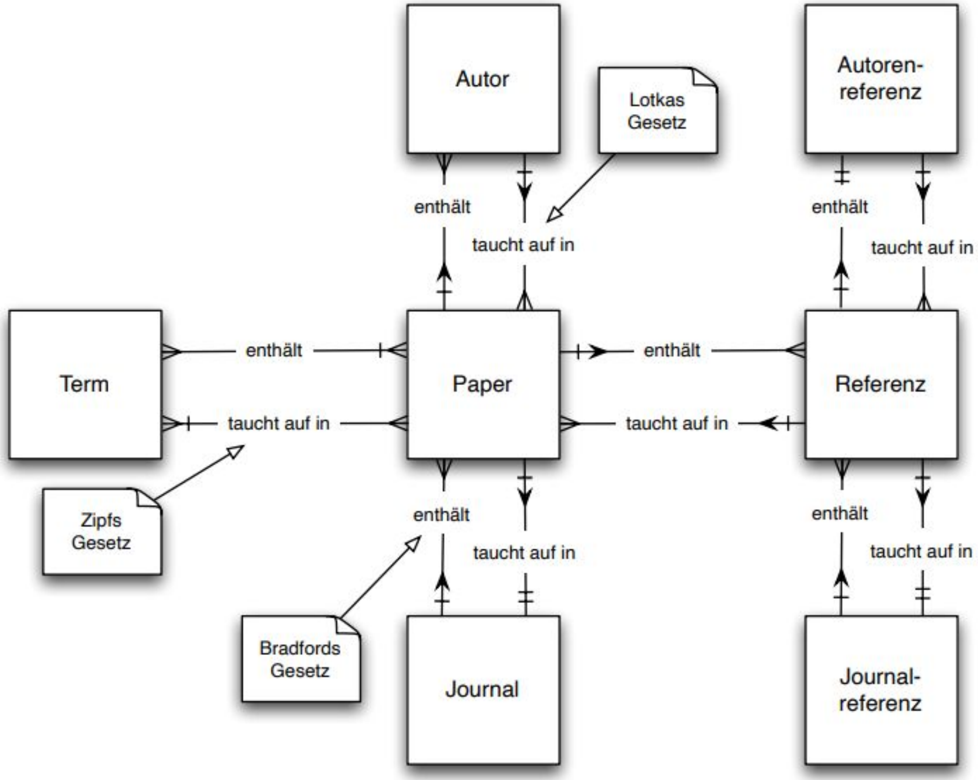
(a) Distribution of Citation Search in sessions

(b) Distribution of Footnote Chase in sessions

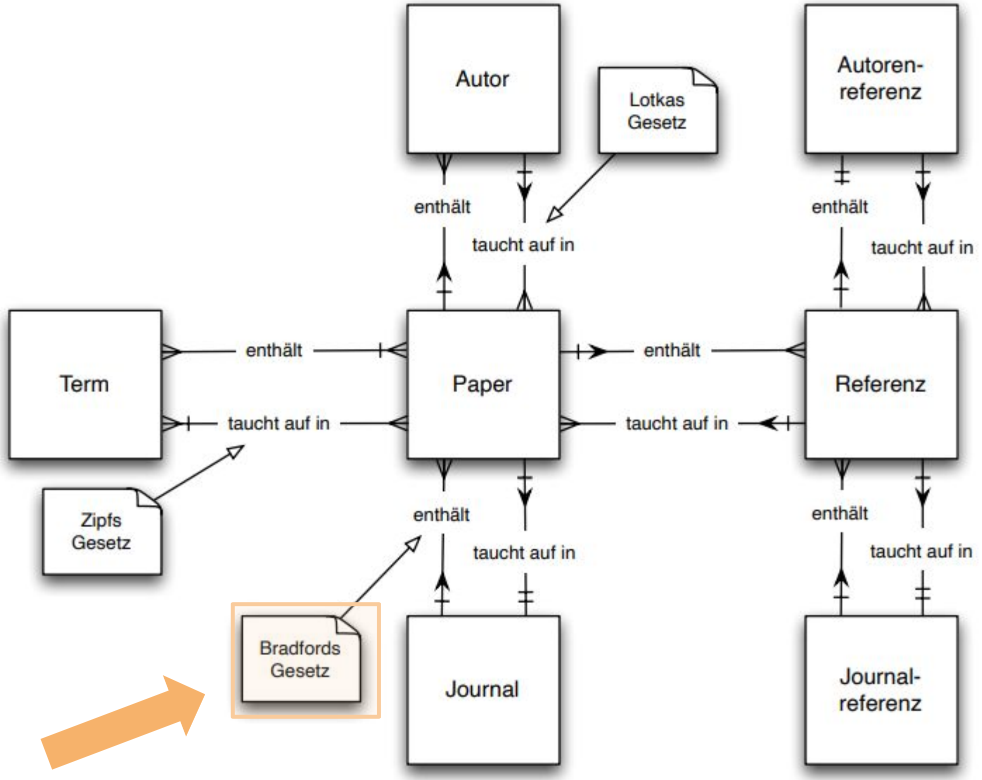
(c) Distribution of Keyword Search in sessions

(d) Distribution of Author Search in sessions

General Approach



General Approach



General Approach

Bradfords Law

- Identifying **Core Journals**
- Boosting Papers by **occurrences** of journal

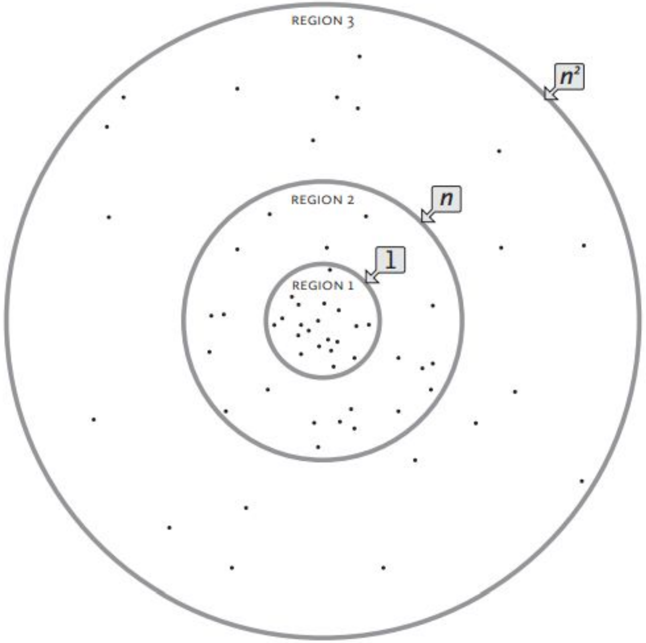
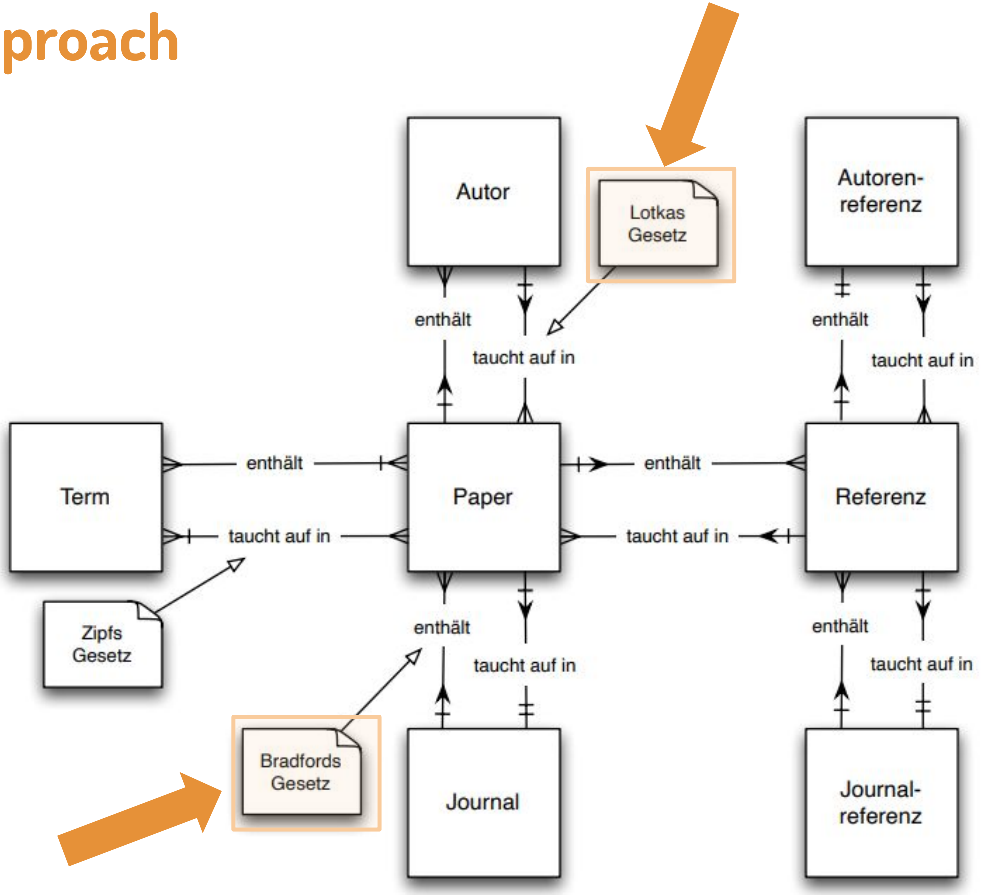


FIG. 1. *The Bradford regions. Each search region contains one-third of the articles on the subject. Each ring is five times the area of the next smaller one.*

Bates, M. J. (2002). https://pages.gseis.ucla.edu/faculty/bates/articles/SearchingBradford.pdf

General Approach



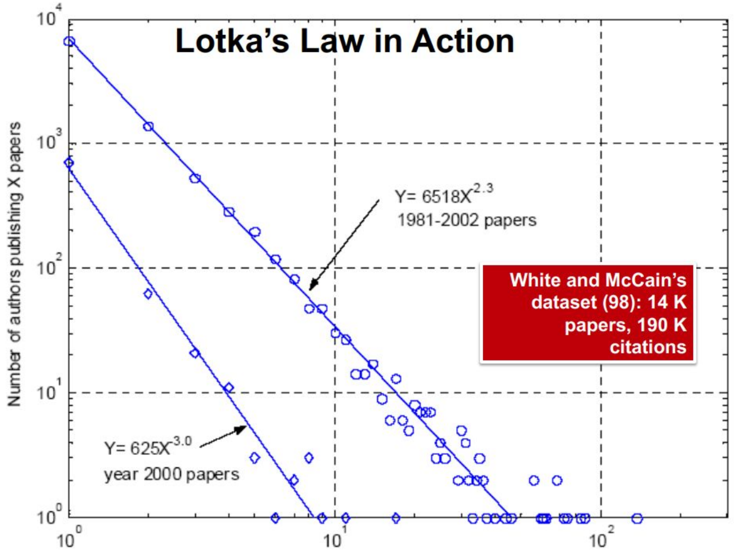
General Approach

Bradfords Law

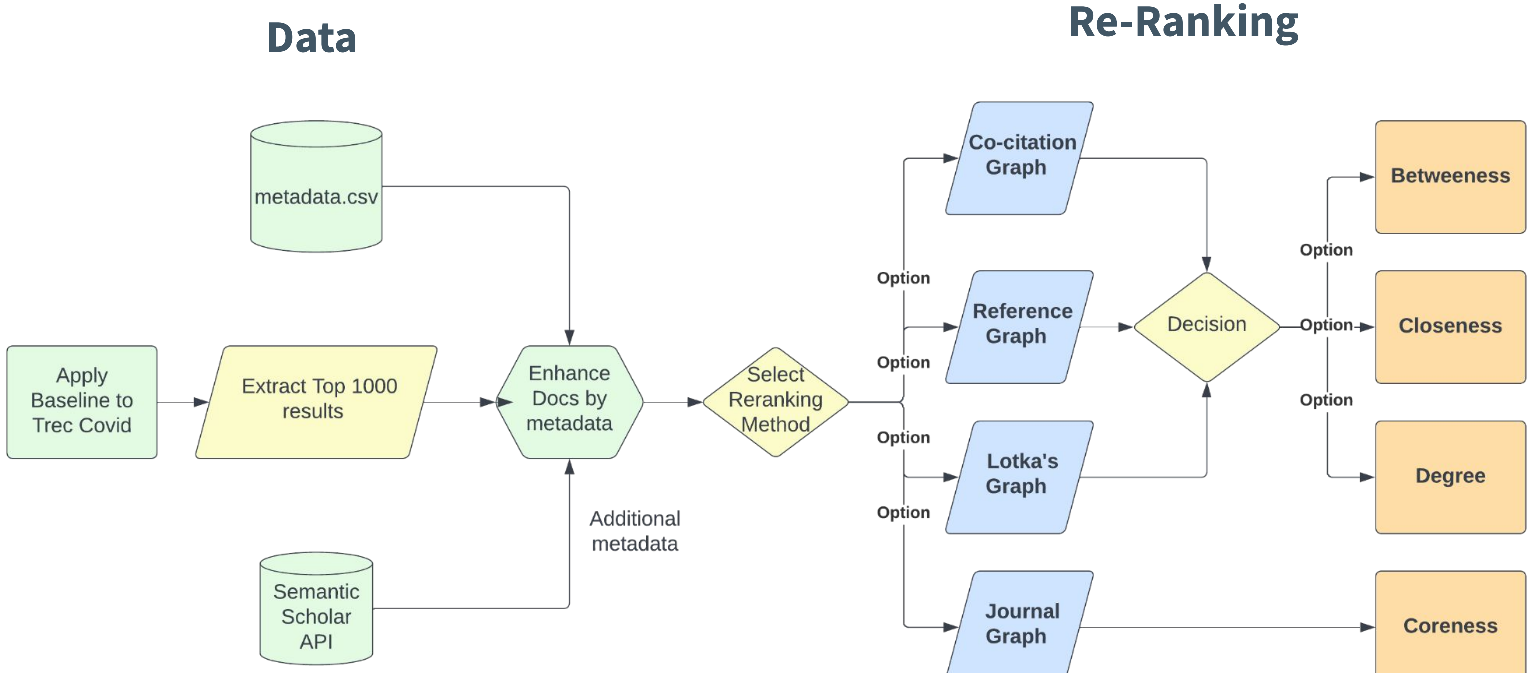
- Identifying Core Journals
- Boosting Papers by occurrence of journal

Lotkas Law

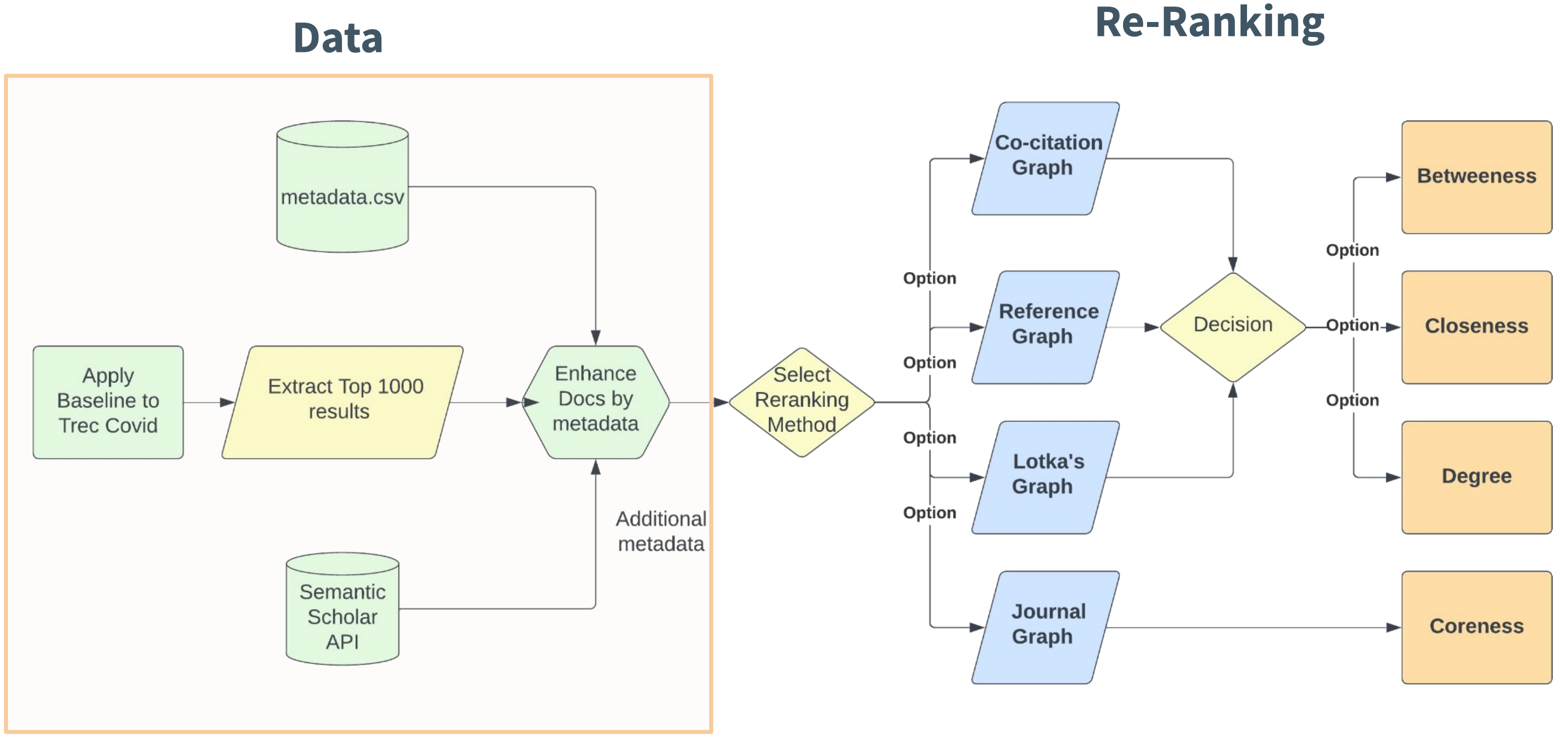
- Creating co-citation and reference graph
- Calculate and compare different graph measures
- Boost by average and maximum measures for **paper authors**



Pipeline


Data
Re-Ranking
metadata.csv
Apply Baseline to Trec Covid
Extract Top 1000 results
Enhance Docs by metadata
Additional metadata
Semantic Scholar API
Select Reranking Method
Option
Option
Option
Option
Co-citation Graph
Reference Graph
Lotka's Graph
Journal Graph
Decision
Option
Option
Option
Betweeness
Closeness
Degree
Coreness

Pipeline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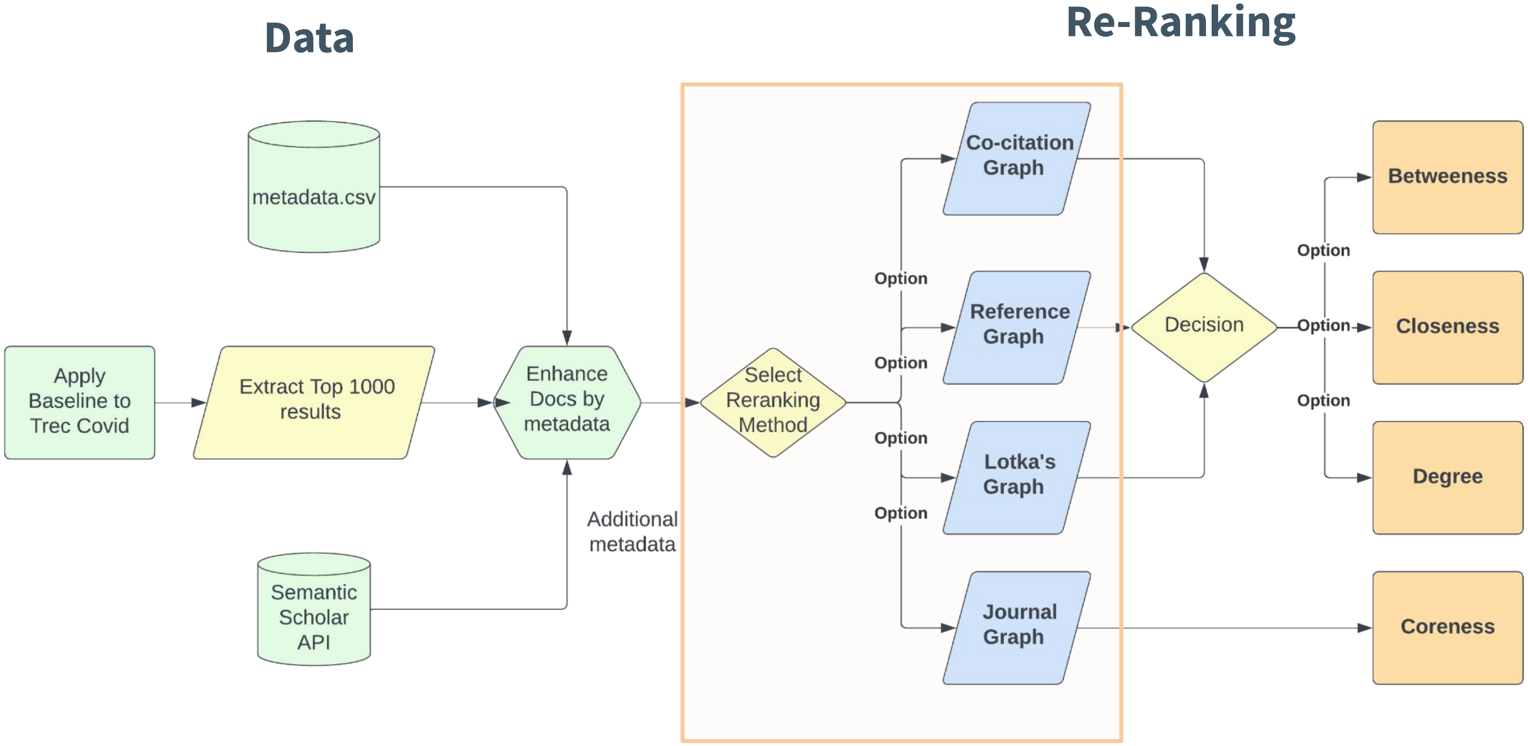
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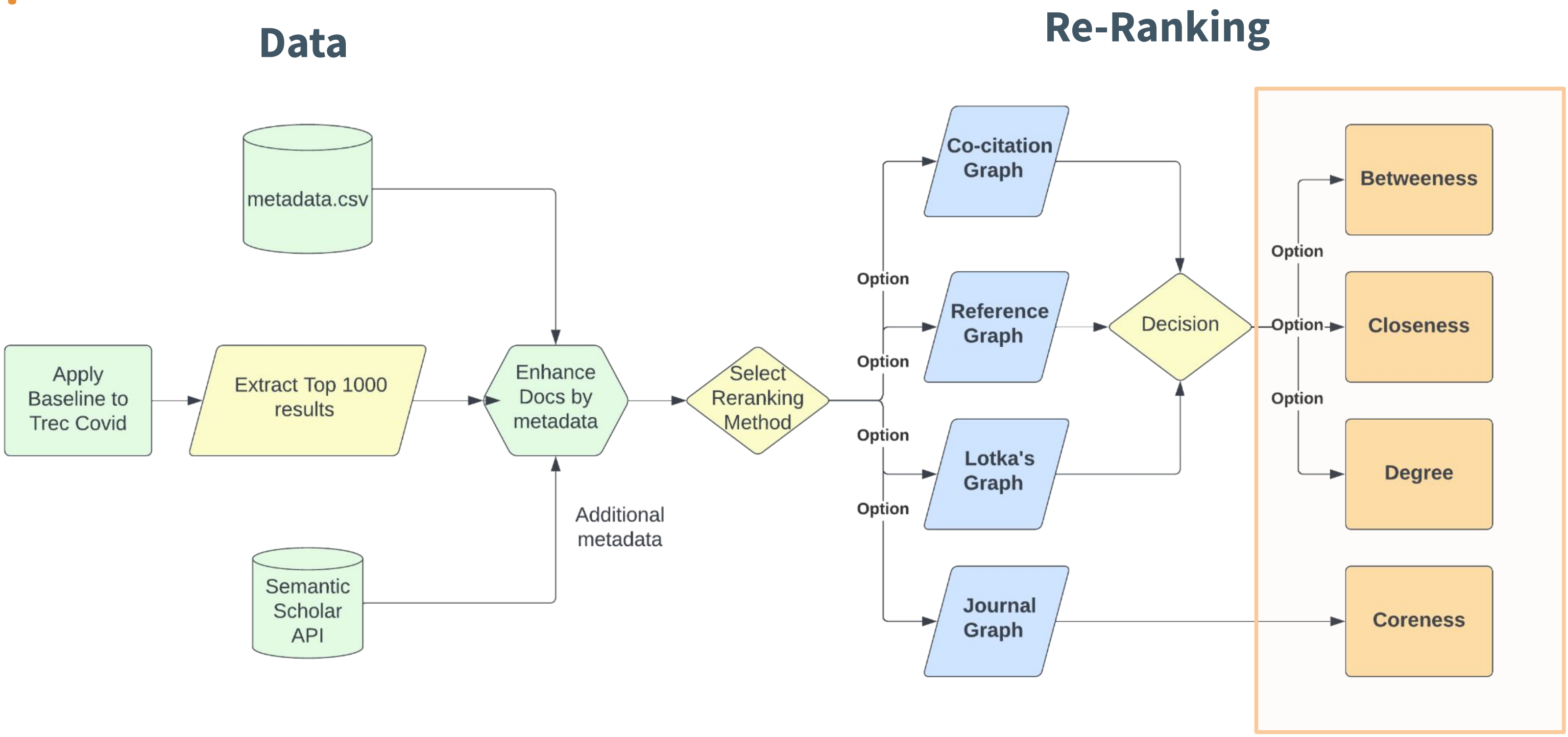
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2. Creating a Baseline

Creating a Baseline

Cord-19

Data Set *(Version 2020-07-16)*

Weighting Model

BM25

Applied fields

title & abstract

Selection of Data

→ *Top 1000* documents per query

→ Removing elements without DOI

→ Removing duplicates

Baseline: Performance

Cord-19 Data Set

(Version 2020-07-16), ***Query 1**: 'coronavirus origin'*

Run Name	map	P@20	Recall@20	MRR	ndcg_cut_20
Baseline	0.1028	0.7	0.02	0.5	0.5219

Weighting Model

BM25

Applied fields

title & abstract

3. Data Preparation

Data Enrichment

Enrichening metadata
with *Semanticscholar API*

Metadata used

Authors

- *authors.name*
- *authors.affiliations*
- *authorId*

Papers

- *fieldsOfStudy*
- *s2FieldsOfStudy*
- *Citations.authors*
- *paperId*
- *Journal*

4. Creating Graphs

Creating Graphs

Creating various graphs and their bibliometric measures

1. **Co-citation** Graph
2. **Lotka**-**inspired** Graph
3. **Citation** Graph
   a. Between authors
   b. Between papers
4. **Journal** Graph

Co-citation Graph

Co-authors with

Author → **Author**

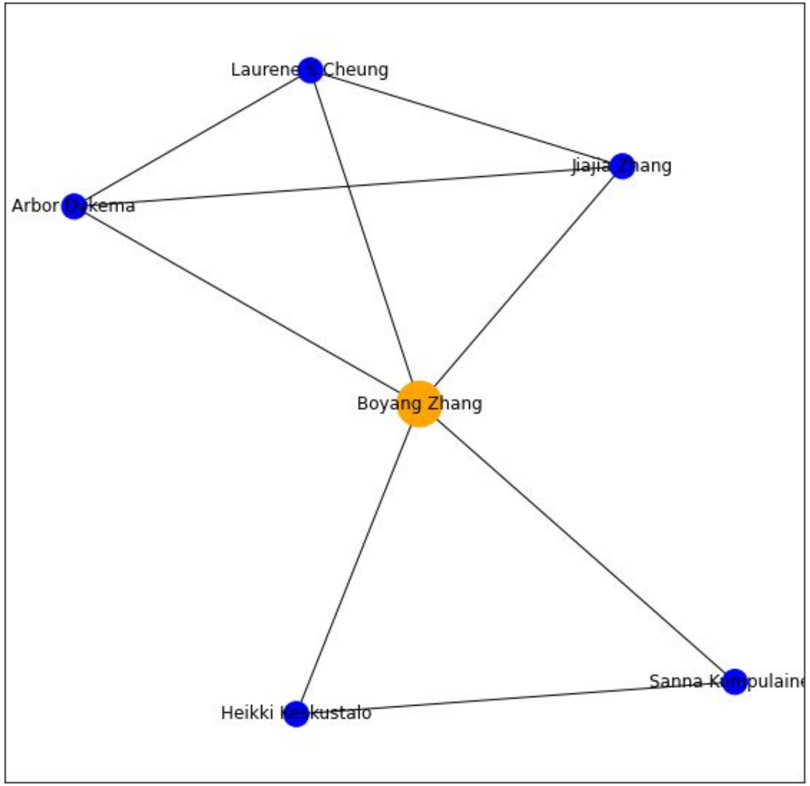
→ Undirected Relationship

ID

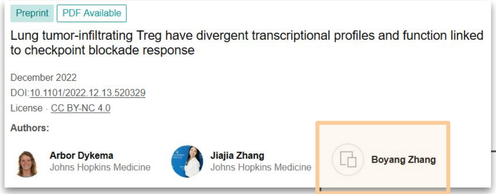
→ By authorId

Relevant fields

→ authorId



Co-citation Graph


Preprint PDF Available
Lung tumor-infiltrating Treg have divergent transcriptional profiles and function linked to checkpoint blockade response
December 2022
DOI:10.1101/2022.12.13.520329
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https://www.researchgate.net/publication/366328313_Lung_tumor-infiltrating_Treg_have_divergent_transcriptional_profiles_and_function_linked_to_checkpoint_blockade_response

Co-authors with

Author ➔ **Author**

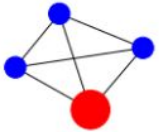
➔ Undirected Relationship

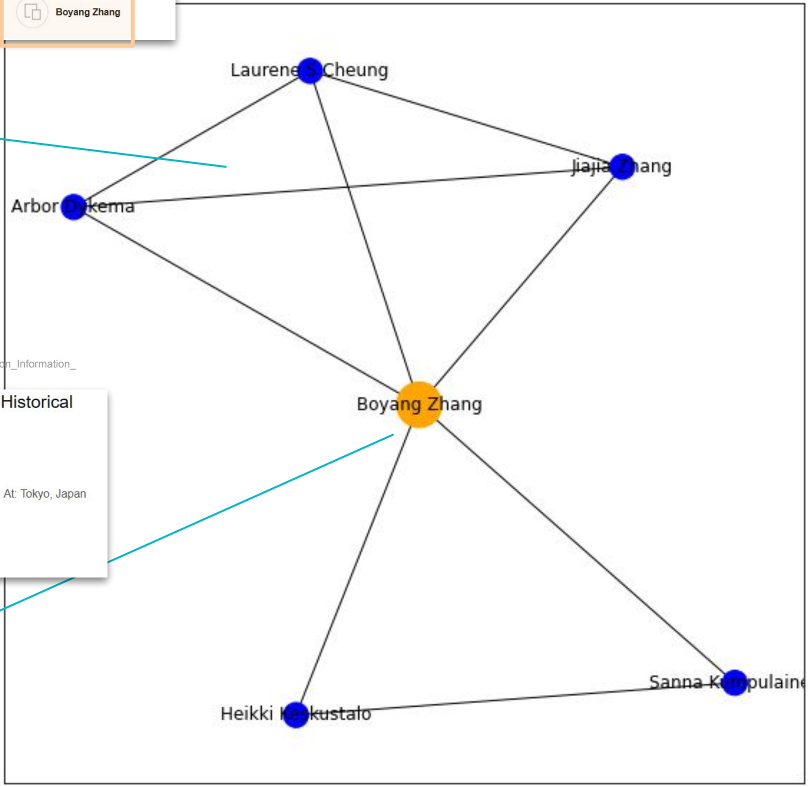
ID

➔ By authorId

Relevant fields

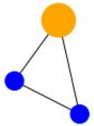
➔ authorId





https://www.researchgate.net/publication/354005593_A_Review_on_Information_Retrieval_in_the_Historical_and_Digital_Humanities_Domain


A Review on Information Retrieval in the Historical and Digital Humanities Domain
July 2021
DOI:10.22492/issn.2186-229X.2021.1
Conference: The Asian Conference on Arts & Humanities 2021 · At: Tokyo, Japan
Authors:
Boyang Zhang



However: Potential conflict

➔ Same name, different persons

➔ In different research fields

Lotka-inspired Graph

written by

Paper ➔ **Author**

➔ Directed Relationship

ID

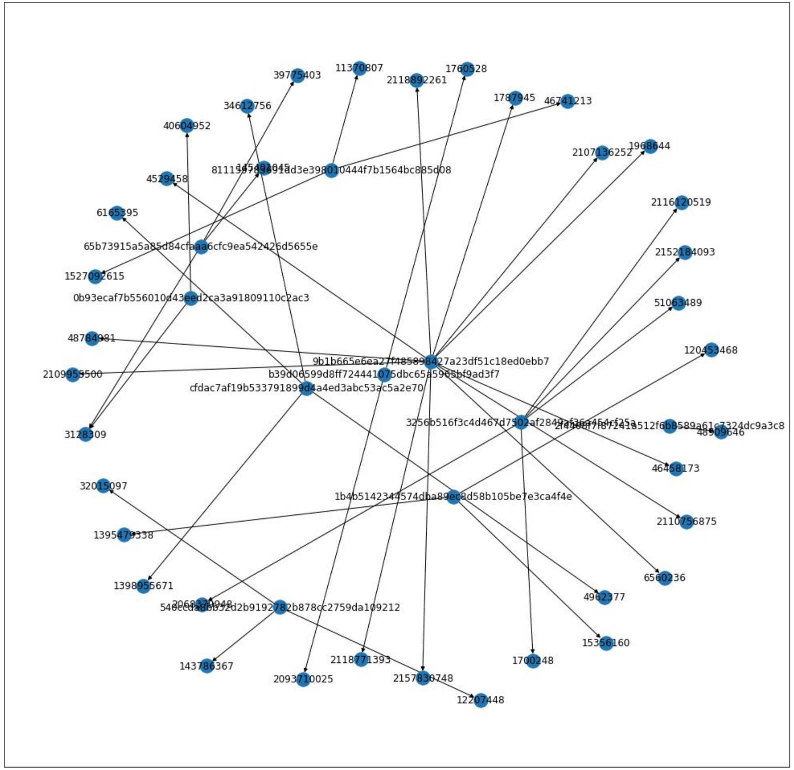
➔ By authorId

Relevant fields

➔ authorId

➔ paperId

➔ Highlights author prominent in many papers



$n_{Papers} = 10$

Enriched Lotka-inspired Graph

written by

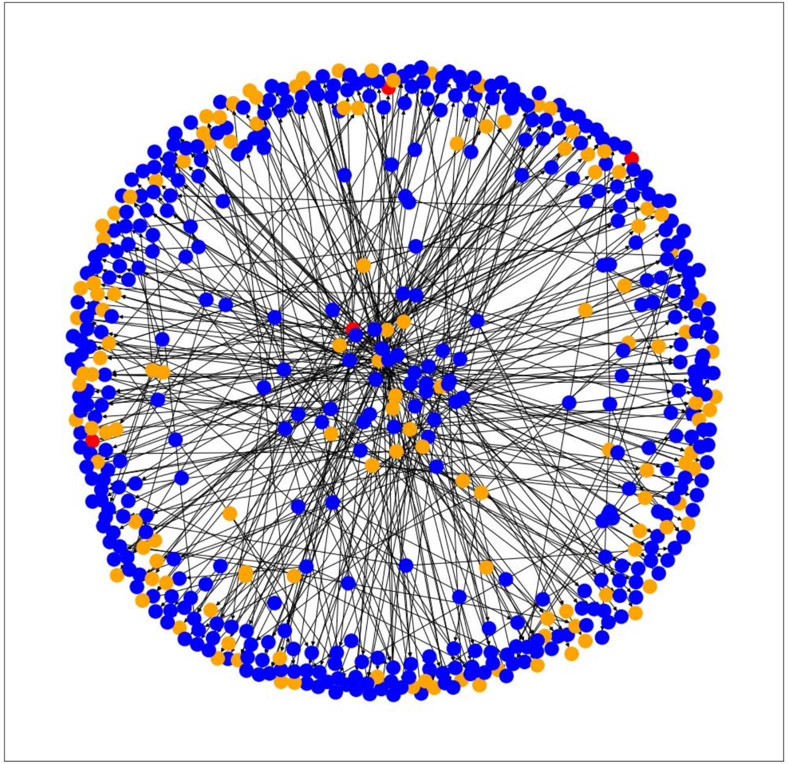
Paper → **Author**

→ Directed Relationship

Secondary Relationships

→ Related authors through citations in the papers

→ Highlights authors prominent in many papers



$n_{Papers} = 2$

Enriched Lotka-inspired Graph

written by

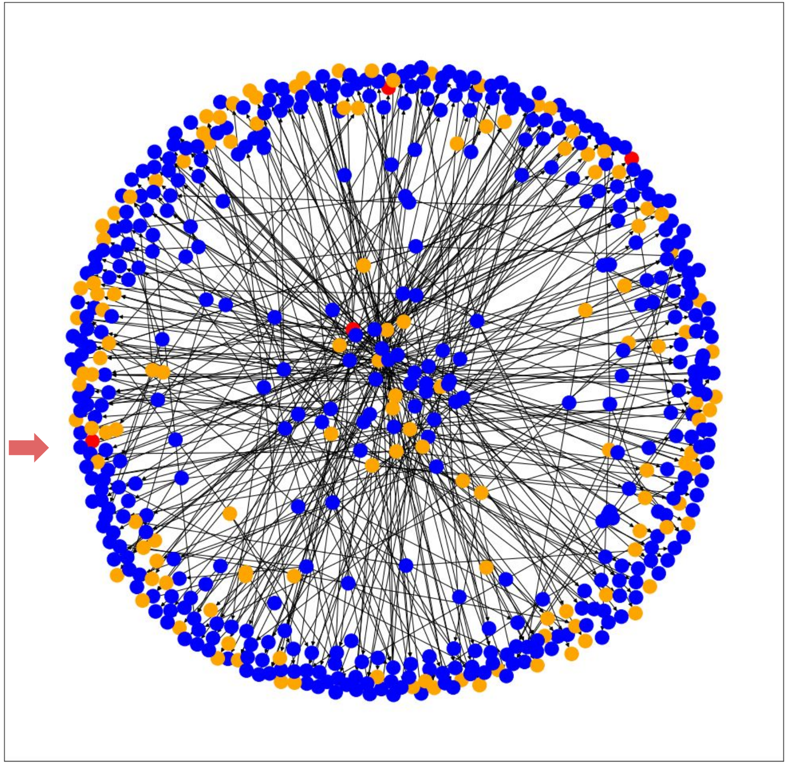
Paper → Author

→ Directed Relationship

Secondary Relationships

→ Related authors through citations in the papers

→ Highlights authors prominent in many papers



$n_{Papers} = 2$

Citation Graph (between Authors)

Based on

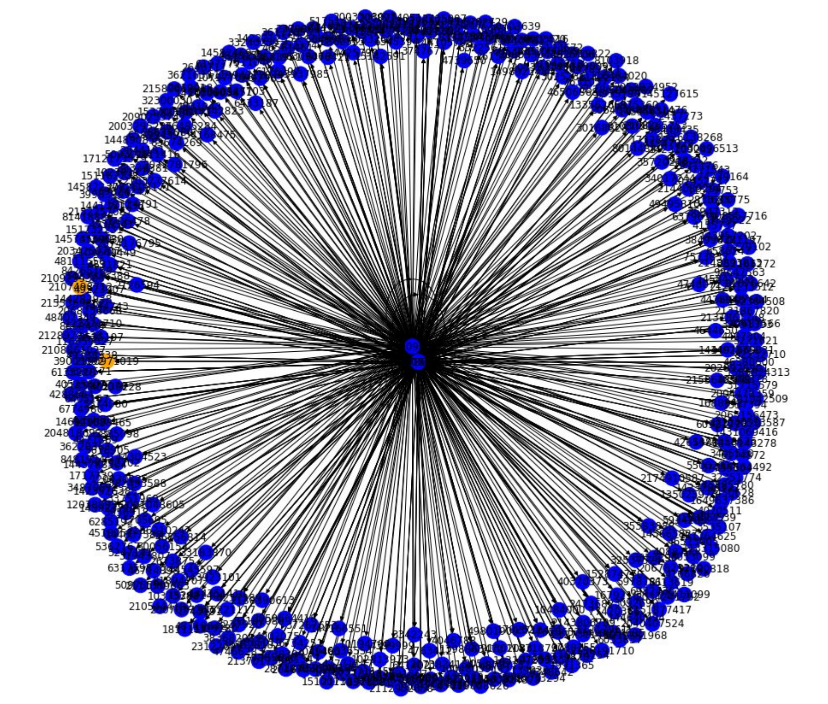
Author $\xrightarrow{\text{cites}}$ Author

→ Directed Relationship

Describes

→ The source of **citations**

→ **Authors** that often get cited



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Citation Graph (between Authors)

Based on

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→ Directed Relationship

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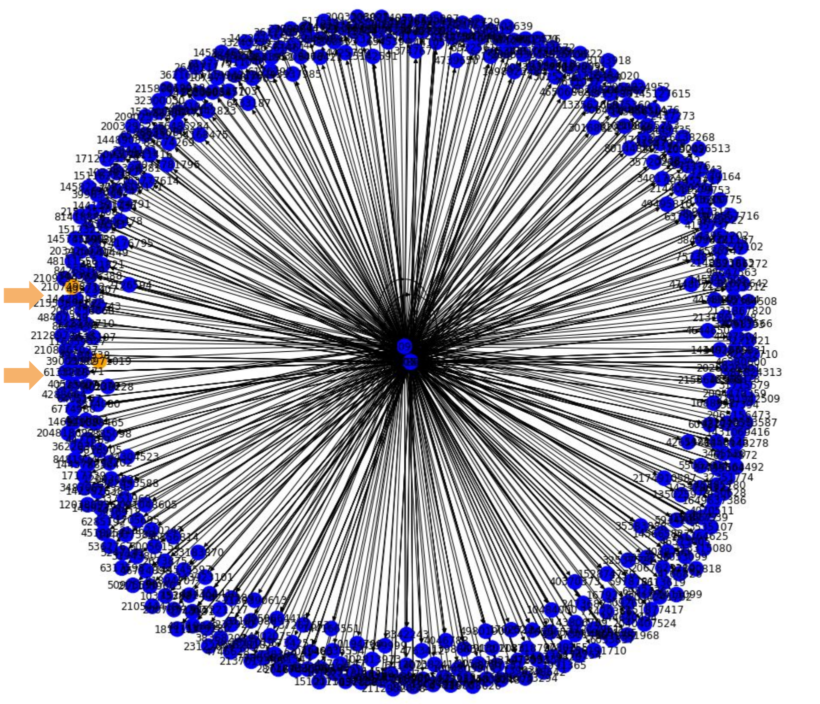


$n_{Authors} = 2$

Citation Graph (between Papers)

Based on

Paper $\xrightarrow{\text{references}}$ **Paper**

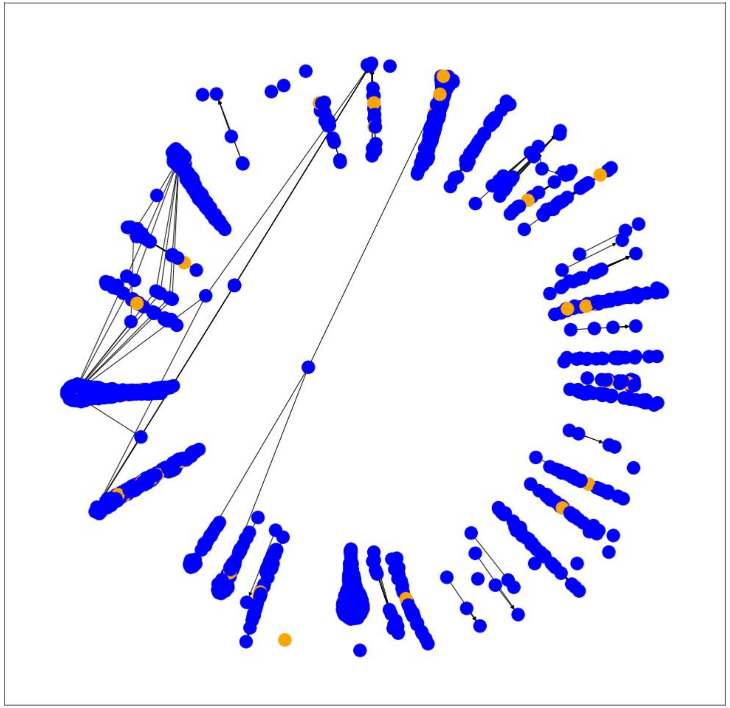
→ Directed Relationship

Describes

→ Direction of **references**

→ **Papers** that often get **references**

→ Distinctive reciprocal citation clusters



$n_{Papers} = 50$

Citation Graph (between Papers)

Based on

Paper $\xrightarrow{\text{references}}$ **Paper**

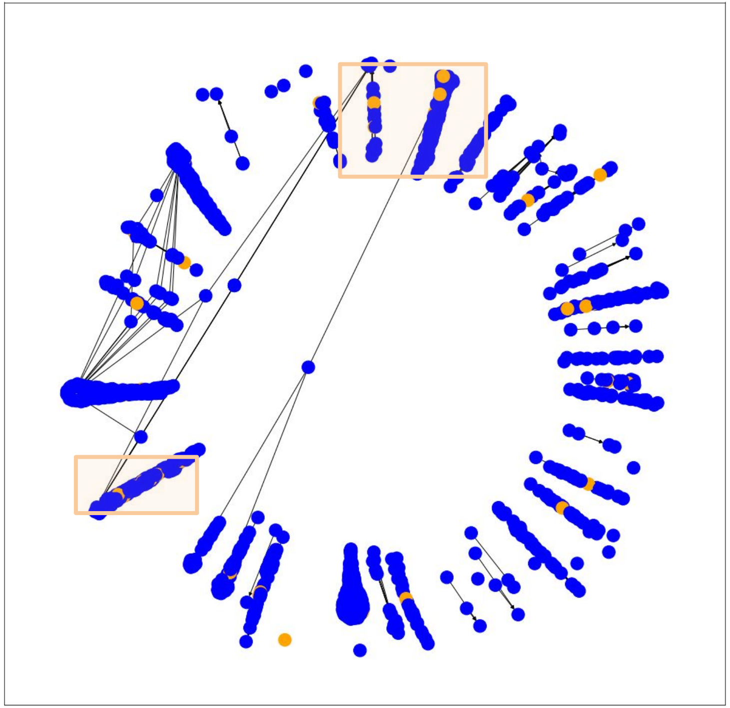
→ Directed Relationship

Describes

→ Direction of **references**

→ **Papers** that often get **references**

→ Distinctive reciprocal citation clusters



$n_{\text{Papers}} = 50$

Journal Graph

Based on

is part of

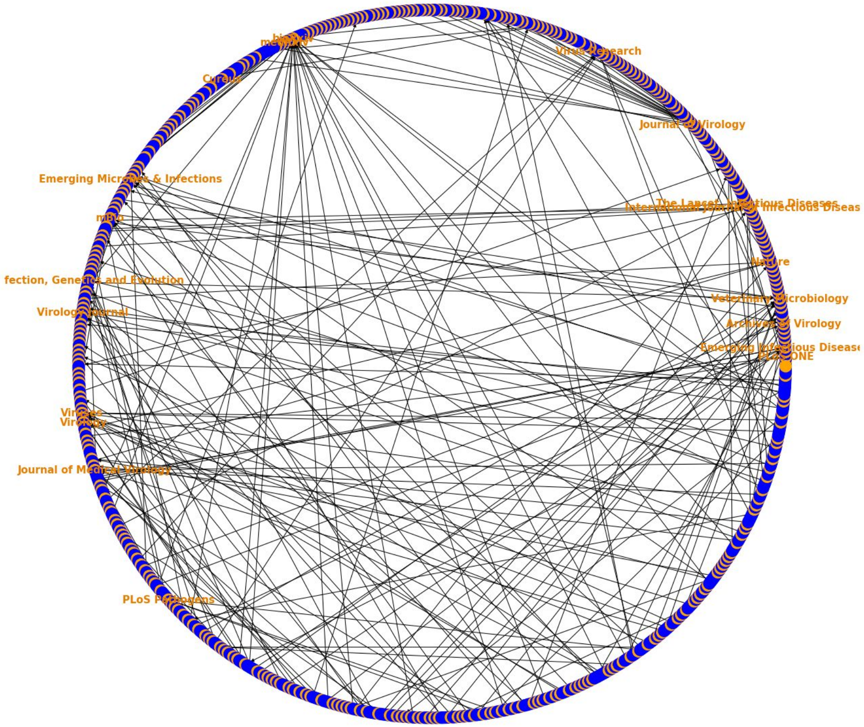
Paper ➔ Journal

➔ Directed Relationship

Describes

➔ Prominent **Core Journals** that feature most papers

➔ Visualizes the influence of a core journal in the subject



$n_{Papers} = 596$

5. Experiments & Evaluation

Observing the effects of boosting in re-ranking

Centrality Measures

Degree Centrality

- Dfss

Betweenness Centrality

- Fdas

Closeness Centrality

Experiments

Boost by

→ maximum {centrality measure} from **author/papers/journals**

Boost by

→ average {centrality measure} from **all authors/papers/journals**

Boost by connection to **most popular author**

→ For *high/low* distance

...in the re-ranking process

Evaluation

Execute PyTerrier Runs on

→ Experimental graphs with bibliometrical metadata

1. Author co-citation
2. Author popularity
3. Citation between papers
4. Journal Coreness

Compare IR metrics

→ [map], [P@10], [P@20], [P@100], [Recall@20], [Recall@100] [RecipRank], [ndcg_cut _20]

Results: Author Co-Citation

Based on → centrality

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.5	0.519000
reranker_degree_mean	0.103915	0.9	0.70	0.48	0.020029	0.068670	0.5	0.524213
reranker_degree_max	0.103710	0.8	0.60	0.50	0.017167	0.071531	0.5	0.487725
reranker_closeness_mean	0.103760	0.8	0.65	0.51	0.018598	0.072961	0.5	0.499142
reranker_closeness_max	0.105412	0.8	0.65	0.52	0.018598	0.074392	1.0	0.579050
reranker_betweeness_mean	0.103230	0.9	0.70	0.48	0.020029	0.068670	0.5	0.525544
reranker_betweeness_max	0.102602	0.8	0.70	0.49	0.020029	0.070100	1.0	0.563768

→ Slight increases in [*map, recip_rank & recall@100 & ndcg*]

Results: Author Popularity

Based on

➔ Distance to most popular author

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.50	0.519000
reranker_most_popular_user_high_dist_mean	0.092684	0.7	0.70	0.46	0.020029	0.065808	1.00	0.561533
reranker_most_popular_user_high_dist_max	0.092689	0.7	0.70	0.46	0.020029	0.065808	1.00	0.561533
reranker_most_popular_user_short_dist_mean	0.092371	0.4	0.60	0.40	0.017167	0.057225	0.50	0.329489
reranker_most_popular_user_short_dist_max	0.091112	0.3	0.55	0.40	0.015737	0.057225	0.25	0.294177

No log + cutoff 10

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.5	0.519000
reranker_most_popular_user_high_dist_mean	0.103087	0.8	0.70	0.49	0.020029	0.070100	1.0	0.603958
reranker_most_popular_user_high_dist_max	0.103077	0.8	0.70	0.49	0.020029	0.070100	1.0	0.604214
reranker_most_popular_user_short_dist_mean	0.101879	0.6	0.65	0.48	0.018598	0.068670	0.5	0.477122
reranker_most_popular_user_short_dist_max	0.101573	0.6	0.65	0.47	0.018598	0.067239	0.5	0.475326

Log10 , cutoff 10

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.5	0.519000
reranker_most_popular_user_high_dist_mean	0.103023	0.8	0.70	0.49	0.020029	0.070100	1.0	0.603958
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reranker_most_popular_user_short_dist_mean	0.103076	0.7	0.60	0.49	0.017167	0.070100	0.5	0.462294
reranker_most_popular_user_short_dist_max	0.103077	0.7	0.65	0.50	0.018598	0.071531	0.5	0.476451

Log10, cutoff 5

➔ Boosting by short distance to most popular author worsens the results

➔ Boosting by long distance slightly increases [*map, recip_rank, ndcg*]

Results: Author Popularity

Based on

➔ Distance to most popular author

No log+ cutoff 10

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reranker_most_popular_user_high_dist_mean	0.103023	0.8	0.70	0.49	0.020029	0.070100	1.0	0.603958
reranker_most_popular_user_high_dist_max	0.102999	0.8	0.70	0.49	0.020029	0.070100	1.0	0.604214
reranker_most_popular_user_short_dist_mean	0.103076	0.7	0.60	0.49	0.017167	0.070100	0.5	0.462294
reranker_most_popular_user_short_dist_max	0.103077	0.7	0.65	0.50	0.018598	0.071531	0.5	0.476451

➔ Boosting by short distance to most popular author worsens the results

➔ Boosting by long distance slightly increases [*map, recip_rank, ndcg*]

Results: Author Popularity

Based on

➔ Distance to most popular author

Log10 + cutoff 10

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.50	0.519000
reranker_most_popular_user_high_dist_mean	0.092684	0.7	0.70	0.46	0.020029	0.065808	1.00	0.561533
reranker_most_popular_user_high_dist_max	0.092689	0.7	0.70	0.46	0.020029	0.065808	1.00	0.561533
reranker_most_popular_user_short_dist_mean	0.092371	0.4	0.60	0.40	0.017167	0.057225	0.50	0.329489
reranker_most_popular_user_short_dist_max	0.091112	0.3	0.55	0.40	0.015737	0.057225	0.25	0.294177

Log10 , cutoff 10

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.5	0.519000
reranker_most_popular_user_high_dist_mean	0.103087	0.8	0.70	0.49	0.020029	0.070100	1.0	0.603958

Log10, cutoff 5

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.70	0.49	0.020029	0.070100	0.5	0.519000
reranker_most_popular_user_high_dist_mean	0.103023	0.8	0.70	0.49	0.020029	0.070100	1.0	0.603958
reranker_most_popular_user_high_dist_max	0.102999	0.8	0.70	0.49	0.020029	0.070100	1.0	0.604214
reranker_most_popular_user_short_dist_mean	0.103076	0.7	0.60	0.49	0.017167	0.070100	0.5	0.462294
reranker_most_popular_user_short_dist_max	0.103077	0.7	0.65	0.50	0.018598	0.071531	0.5	0.476451

➔ Boosting by short distance to most popular author worsens the results

➔ Boosting by long distance slightly increases [*map, recip_rank, ndcg*]

Results: Lotka-Inspired Graph

Based on

→ activity of an author

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.7	0.49	0.020029	0.07010	0.5	0.519000
reranker_lotka_degree_mean	0.103161	0.9	0.7	0.49	0.020029	0.07010	0.5	0.520775
reranker_lotka_degree_max	0.103370	0.9	0.7	0.48	0.020029	0.06867	0.5	0.523919
reranker_lotka_closeness_mean	0.103345	0.9	0.7	0.49	0.020029	0.07010	0.5	0.521625
reranker_lotka_closeness_max	0.103685	0.9	0.7	0.48	0.020029	0.06867	0.5	0.525544

→ Slight increases in [*map & ndcg_cut@20*]

Results: Citation Graph (between papers)

Based on

→ centrality between papers

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.7	0.49	0.020029	0.070100	0.5	0.519000
reranker_citation_paper_degree	0.104598	0.8	0.7	0.51	0.020029	0.072961	0.5	0.504761
reranker_citation_paper_closeness	0.105153	0.8	0.7	0.52	0.020029	0.074392	1.0	0.514877

→ Slight increases in [*map, recip_rank & recall@100*]

Results: Journal Graph

Based on

→ Coreness of the Journals

name	map	P_10	P_20	P_100	recall_20	recall_100	recip_rank	ndcg_cut_20
Baseline	0.102866	0.9	0.7	0.49	0.020029	0.0701	0.5	0.519000
reranker_graph_coreness	0.106561	0.9	0.8	0.49	0.022890	0.0701	1.0	0.643262

→ Increases in [*map, recall, recip_rank and* ***ndcg_cut@20***]

Results

Run Name	:affix	:weight	map	P@20	Recall@20	MRR	ndcg_cut_20
Baseline	default	-	0.1028	0.7	0.02	0.5	0.5219
Co-Citation	avg. centrality	0.3	0.xxxx	0.xxxx	0.xxxx	0.xxxx	0.xxxx
Co-Citation	max. centrality	0.3	0.xxxx	0.xxxx	0.xxxx	0.xxxx	0.xxxx
Citation	default	0.3	0.xxxx	0.xxxx	0.xxxx	0.xxxx	0.xxxx
Citation	dithered	0.3	0.xxxx	0.xxxx	0.xxxx	0.xxxx	0.xxxx
Journal Coreness	default	1.3	0.xxxx	0.xxxx	0.xxxx	0.xxxx	0.xxxx

6. Conclusion

Conclusion

Observations concerning the boosting of certain metrics in the re-ranking

➔ **Author co-citation:** Leads to ▶ slight increases in **map, recall@100 & ndcg_cut@20**, but leads to worse results in **P@20** and **Recall@20**

➔ **Popularity:** Boosting by **shortest path** to the **most popular node** ▼worsens the results for top results but ▲improves results within the Top 100

Conclusion

Observations concerning the boosting of certain metrics in the re-ranking

- ➔ **Lotka:** Boosting papers according to the **productivity** of an author leads to ▶small gains in **map** and **ndcg_cut_20**, but ▼losses in **recall@100**
- ➔ **Citations between papers:** Results in ▲gains in **map, p@100** and **recall@100**
- ➔ **Coreness:** Improves ranking only ▶slightly with no visible losses

Lesson's learned

NetworkX's bad scalability for extensive graph analysis

- ➔ External programs such as GraphVis, Cytoscape, etc. might be more suitable

Semanticscholar API

- ➔ lead to insufficient metadata for **Field of Science (FOS)** and **Affiliations** for Graph Analysis

Future Work

Limited scope

- → Encorporate graphs of other topic queries
- → Apply and compare with a more robust baseline

Limited Interactivity

- → NetworkX graphs only allow static views of graphs

Contributions

Andreas Kruff:

Research, Preprocessing, Implementation of Graphs & Metrics, Visualizations of Graphs

Anh Huy Tran:

Research, Implementation of Metrics, Experiments, Analysis and Evaluation of Experiments

References

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[2] Sahraoui, A. K. & Mayr, P. (2018, März). *Users are not influenced by high impact and core journals while searching*. https://www.researchgate.net. Abgerufen am 28. November 2022, von https://www.researchgate.net/publication/324562131_Users_are_not_influenced_by_high_impact_and_core_journals_while_searching

THANKS FOR LISTENING!

Any questions?