

# **Data Mining and Information Extraction Methods for Large-Scale High Quality Representations of Scientific Publications**

**Disputation**

Tarek Saier | 22. April 2024



Data Mining and Information Extraction Methods  
for Large-Scale High Quality  
**Representations of Scientific Publications**

**Data Mining and Information Extraction Methods  
for Large-Scale High Quality  
Scholarly Data**

## Scholarly Data

## ■ Usage

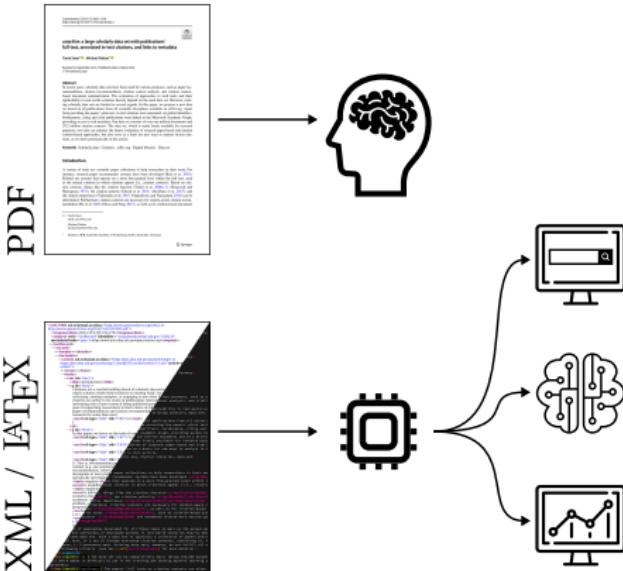
- Services (Search, Recommendation, Stats)
  - ML models (LLMs, summarization, recommender systems)
  - Analyses (temporal, geographic, institutional)

## ■ Flavors

- Metadata (MAG, OpenAlex, ORKG, crossref)
  - Documents (Core, arXMLiv, PMC)
  - Linked Documents (unarXive, S2ORC)

## ■ Data Sources

- PDF (Core, ACL Anthology)
  - XML (PubMed, PLOS, publisher internal)
  - LaTeX (arXiv)



## Motivation

## Background

## Outline

## Corpus

Cit. Netw. & Cross-Ling.  
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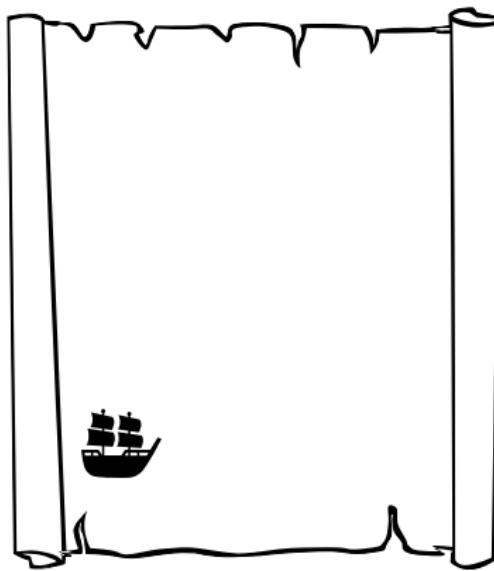
## Parameters

## Conclusion

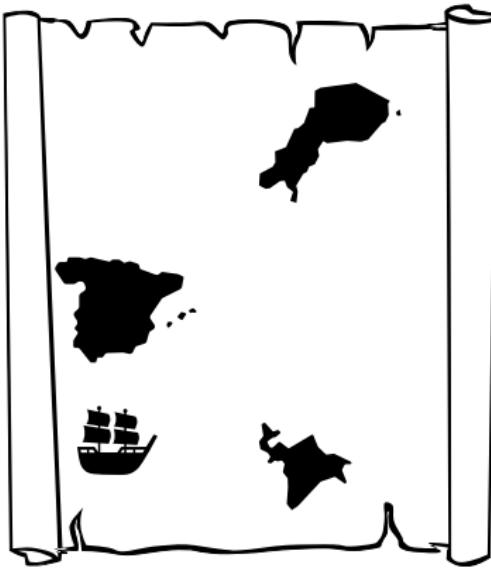
## References

# Analogy

# Maps of the Sea



# Maps of the Sea



## Motivation



## Background

## Outline

## Corpus

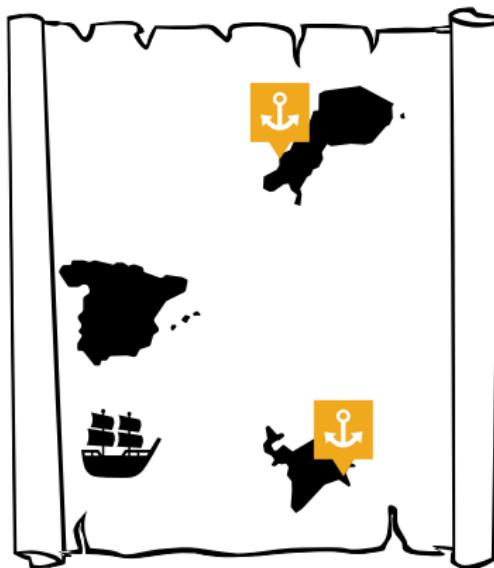
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#### Parameters

## Conclusion

## References

# Maps of the Sea



## Motivation

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## Outline

## Corpus

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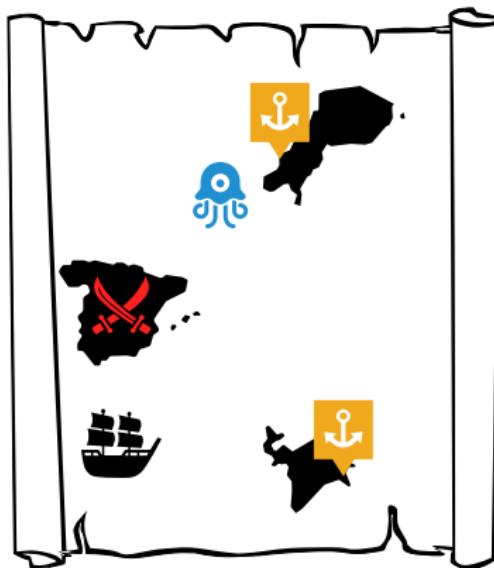
## Parameters

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## Conclusion

## References

# Maps of the Sea



## Motivation



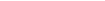
## Background

## Outline

## Corpus

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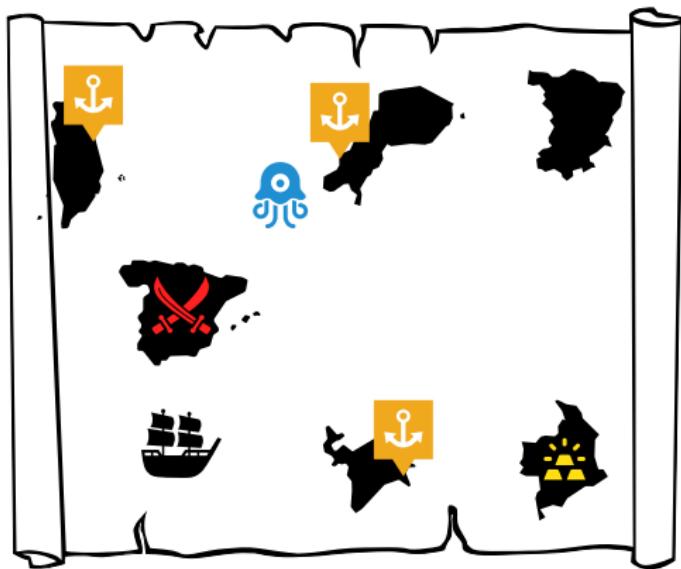
## Parameters



## Conclusion

## References

# Maps of the Sea



## Motivation



## Background

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## Corpus

Cit. Netw. & Cross-Ling.  
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#### Parameters

## Conclusion

## References

# Maps of the Sea / Maps of Science

## The Sailor looks for

- Port to trade
- Island to explore

## The Scientist looks for

- Paper to read
- Venue to publish at
- Research idea to explore

Motivation  
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References

# Maps of the Sea / Maps of Science

## The Trade Company looks for

- Routes to expand
- Ports to build
- Sailor to hire

## The University/Funding Body looks for

- Research to fund
- Researcher to hire
- Policy to establish

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# Maps of the Sea / Maps of Science

**The Trade Company** looks for

- Routes to expand
- Ports to build
- Sailor to hire

**The University/Funding Body** looks for

- Research to fund
- Researcher to hire
- Policy to establish

**better maps<sup>1</sup> ⇒ better decisions**

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<sup>1</sup>Abstract representations of the real world

# Maps of the Sea / Maps of Science

**The Trade Company** looks for

- Routes to expand
- Ports to build
- Sailor to hire

**The University/Funding Body** looks for

- Research to fund
- Researcher to hire
- Policy to establish

**false maps ⇒ misleading/false analyses, models, etc.**

# Maps of the Sea / Maps of Science

**The Trade Company** looks for

- Routes to expand
- Ports to build
- Sailor to hire

**The University/Funding Body** looks for

- Research to fund
- Researcher to hire
- Policy to establish

**our maps of science are insufficient<sup>1</sup>**

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<sup>1</sup>Used data sets are small, incomplete, noisy, etc.

# Maps of the Sea / Maps of Science

**The Trade Company** looks for

- Routes to expand
- Ports to build
- Sailor to hire

**The University/Funding Body** looks for

- Research to fund
- Researcher to hire
- Policy to establish



## Research Objective

Develop methods for generating high-quality scholarly data.

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Data Mining and Information Extraction Methods  
for **Large-Scale High Quality**  
Representations of Scientific Publications

# Maps of Science



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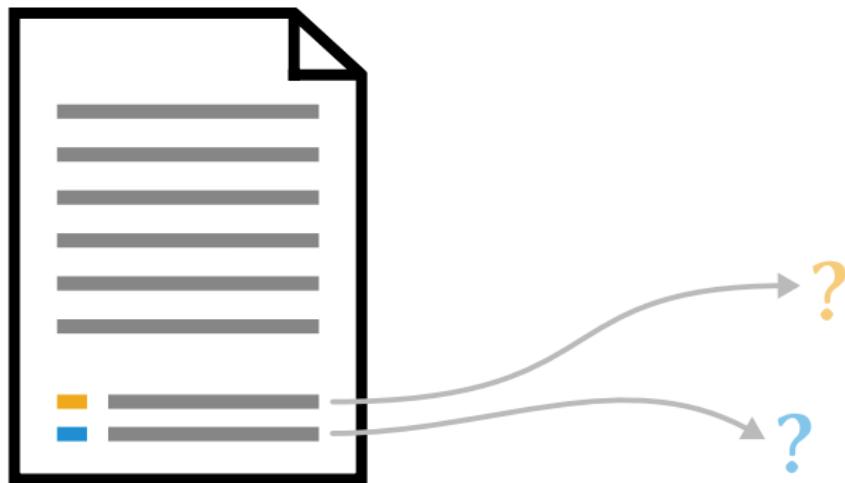
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# Maps of Science



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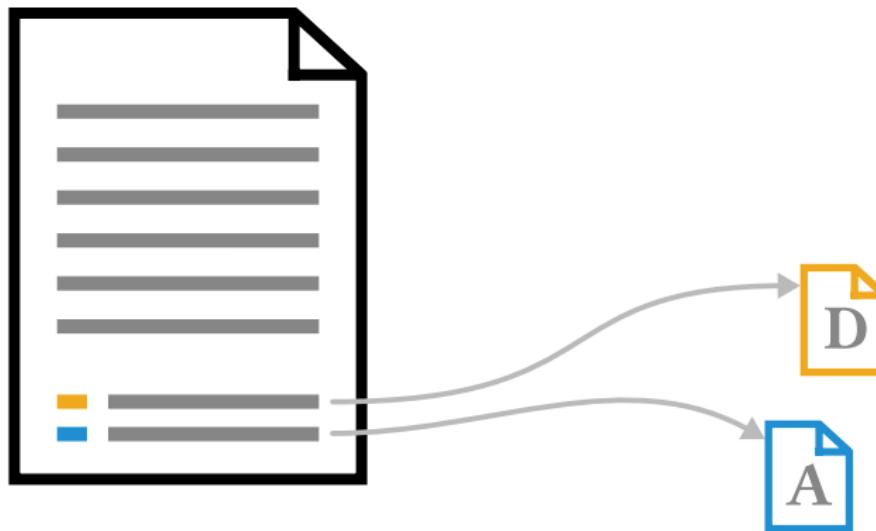
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# Maps of Science



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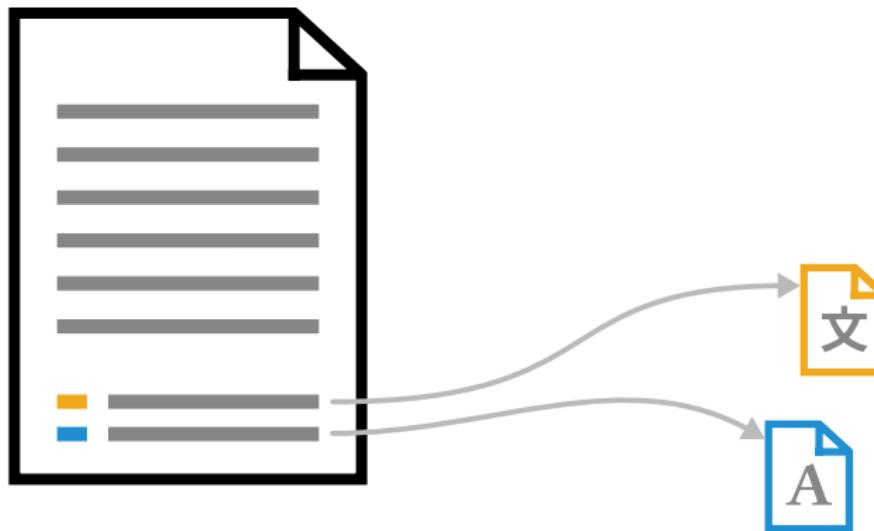
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# Maps of Science



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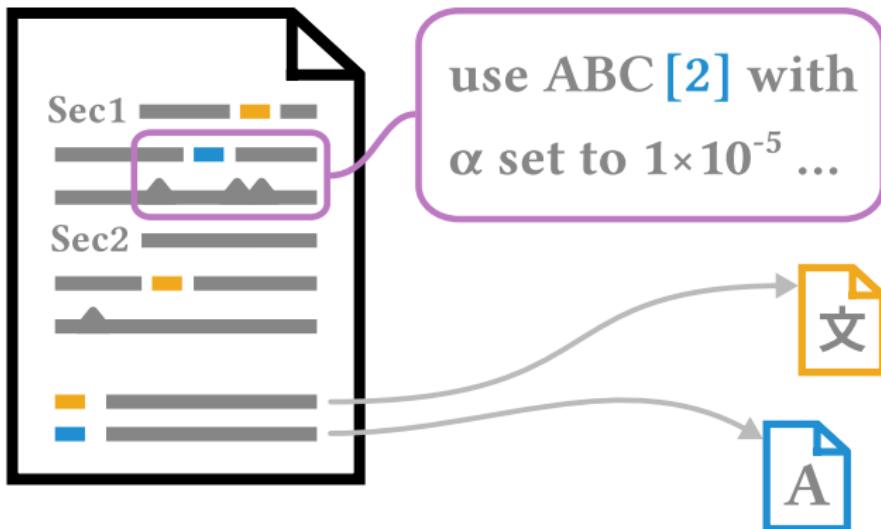
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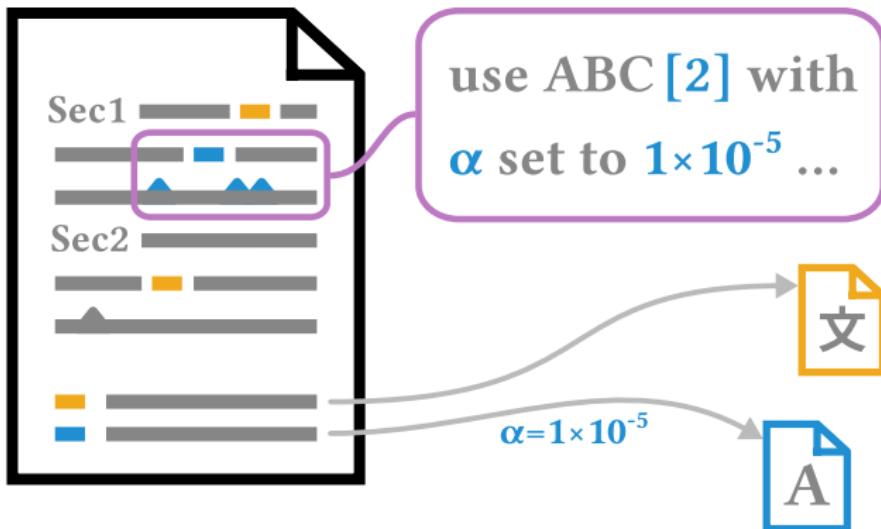
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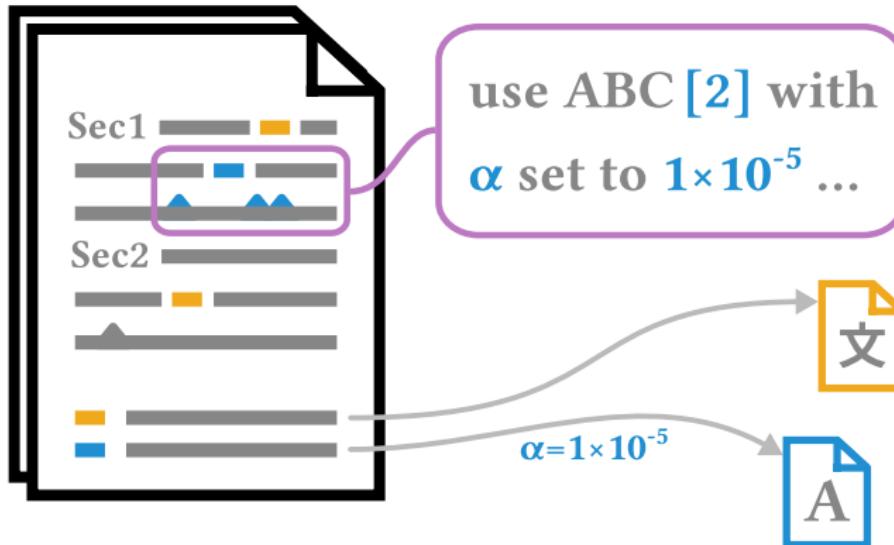
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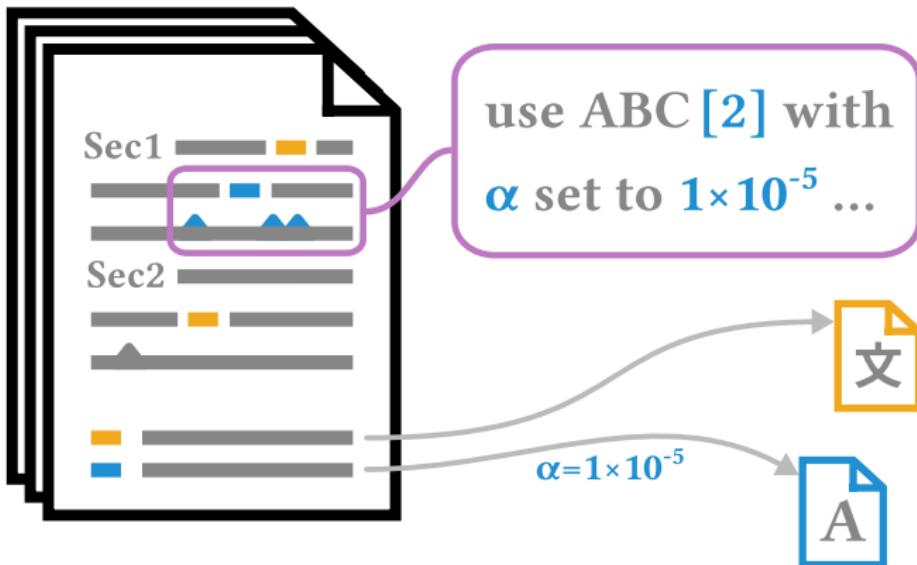
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# Maps of Science



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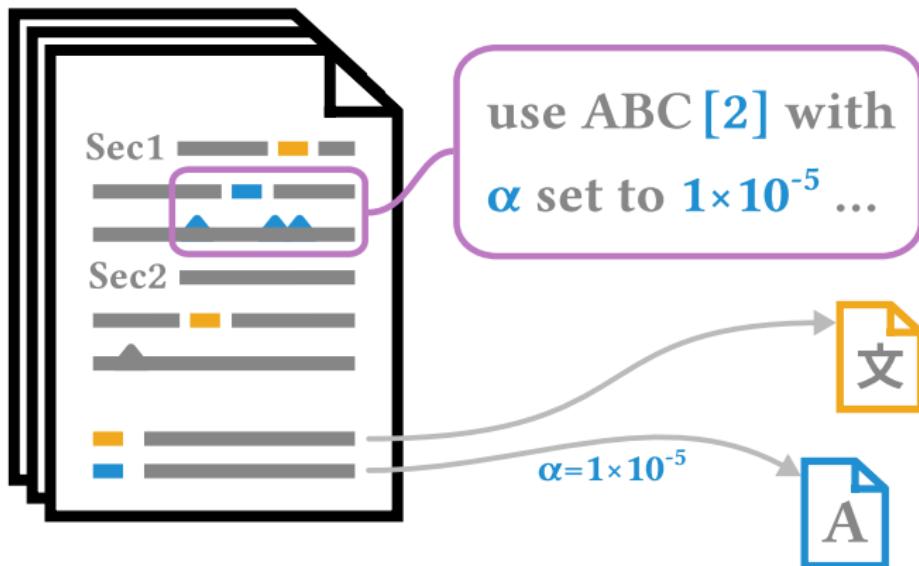
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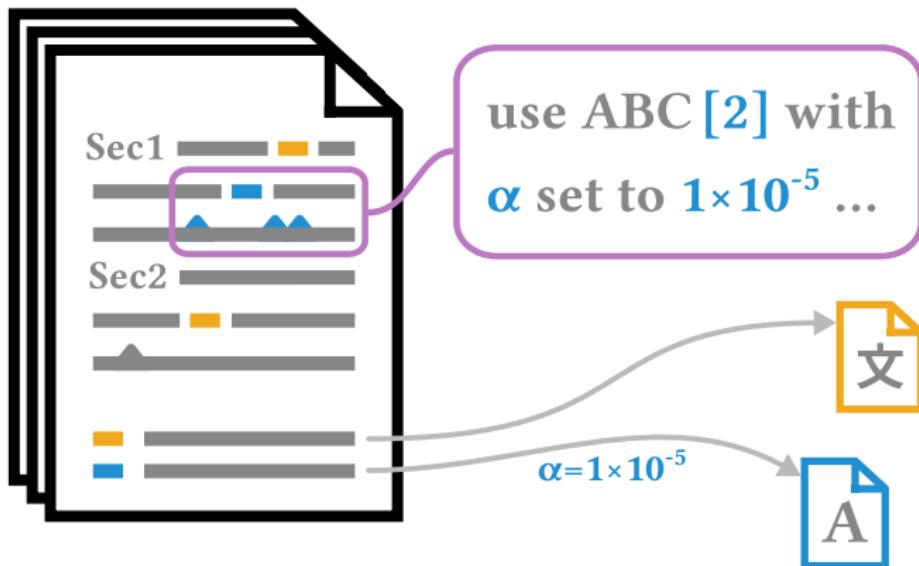
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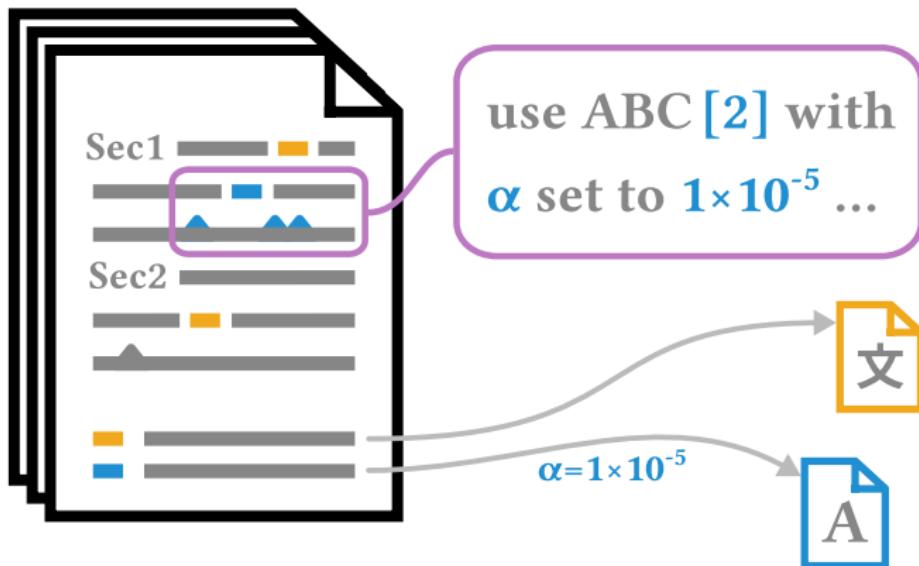
# Research Gap



# Research Gap



# Research Gap





## Research Objective



Data Quality	Base		Research Gap	
	Research Task 1		Research Task 2	
	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>
	✓   X	✓   X	✓   X	✓   X
	✓   X	✓   X	✓   X	✓   X
	✓   X	✓   X	✓   X	✓   X
D <sub>1</sub>	✓   X	✓   X	✓   X	✓   X

# **Data Mining and Information Extraction Methods**

## for Large-Scale High Quality Representations of Scientific Publications

## Citation Network

- ① improved pipeline
- ② blocking method for reference linking



[ULITE'22]  
[JCDL'23]

## Cross-Linguality

- ① extraction method for cross-lingual cit.
- ② extensive analysis



[ICADL'20]  
[IJDL'22]

## Usage Parameters

- ① novel IE task formalization
- ② IE model development



[ECIR'24]

## Corpus

- ① conversion + linking pipeline
- ② extensive analysis



[Scientometrics'20]

## Citation Network

- ① improved pipeline
- ② blocking method for reference linking



[ULITE'22]  
[JCDL'23]

## Cross-Linguality

- ① extraction method for cross-lingual cit.
- ② extensive analysis



[ICADL'20]  
[IJDL'22]

## Usage Parameters

- ① novel IE task formalization
- ② IE model development



[ECIR'24]

## Corpus

- ① conversion + linking pipeline
- ② extensive analysis



[Scientometrics'20]

# Outline

## ■ Corpus

- Challenges
- Solutions
- Resulting Corpus

## ■ Citation Network

## ■ Cross-Linguality

## ■ Usage Parameters

- Task Definition
- Methods
- Results

## ■ Conclusion

- Contributions
- Impact

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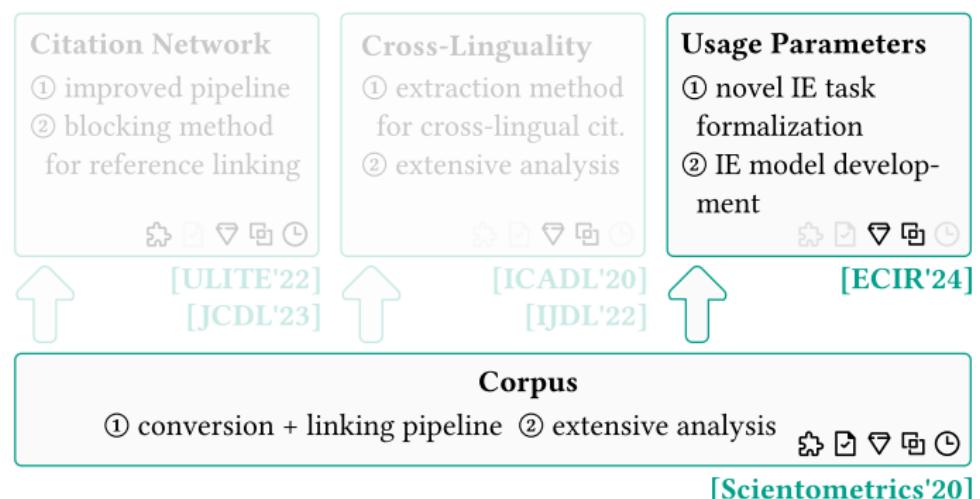
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References



# **Corpus**

**unarXive**

# Corpus - Digest

## ■ Research gap

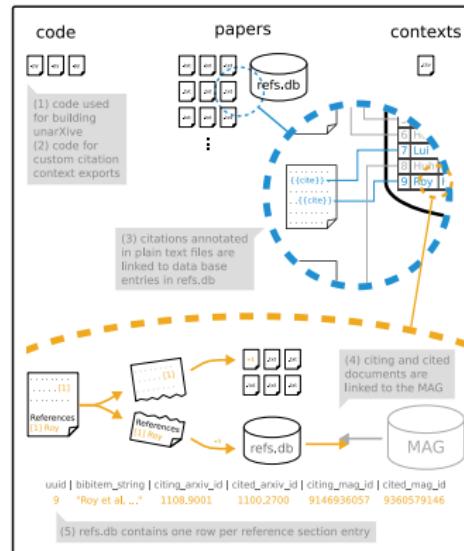
- Corpus size
- Data cleanliness
- Reference linking

## ■ Approach

- Joint handling of text + references
- Conversion of / IE from  $\text{\LaTeX}$
- Reference parsing + linking to MAG

## ■ Results

- Corpus creation methodology
- More extensive, complete; less noisy data
- Large corpus for further research



Scientometrics'20 [1]

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Cit. Netw. & Cross-Ling.  
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# Corpus - Challenges

## ■ General

- Volume ( $\sim 10^6$  docs,  $\sim 10^7$  refs)
- Bridging visual medium and text information

## ■ Parsing

- Parser efficiency
- Typesetting info  $\neq$  semantic info
- $\text{\LaTeX}$  is powerful and people are creative

## ■ Reference linking

- Choice of target set
- Parsing (bb1, not bib)
- Variance and information sparsity

```
\begin{document}
\newcommand{\nc}{\newcommand}
\nc{\be}{\begin{equation}}
\nc{\ee}{\end{equation}}
\nc{\bib}{\bibitem}
```

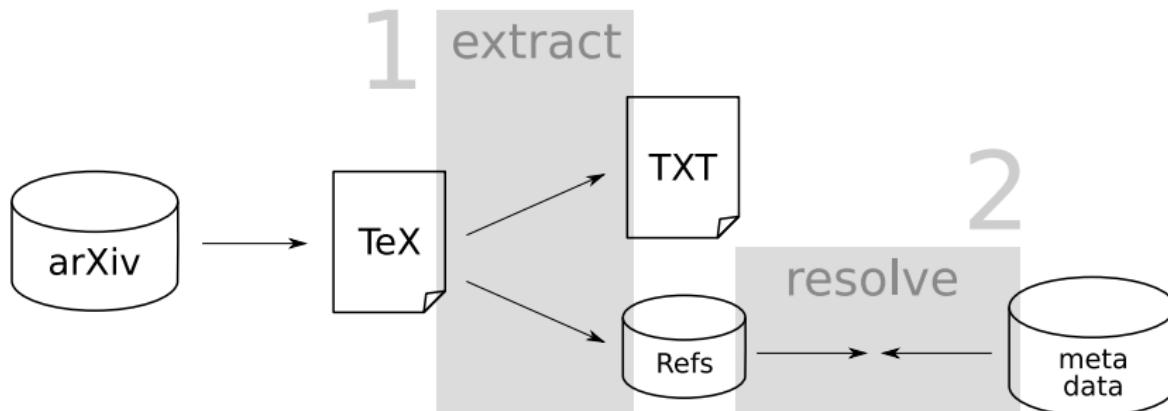
[10] I. Bonalde et al., Phys. Rev. Lett. **85**, 4775 (2000).

[25] Bonalde I, Yanoff B D, Salomon M B, Van Harlingen D J, Chia E M E, Mao Z Q and Maeno Y 2000  
Phys. Rev. Lett. **85** 4775

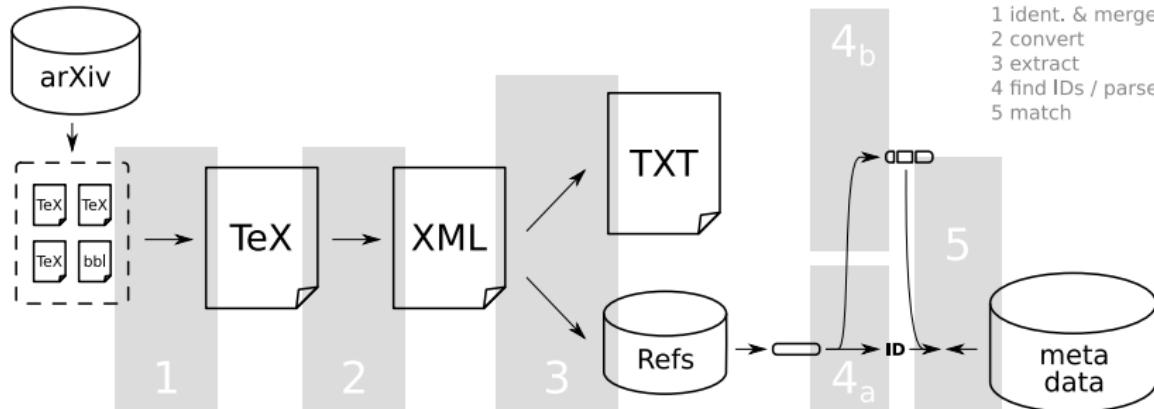
[4] Jaume, S.C. and Sykes, L.R., Pure and Applied Geophysics **155**, 279-305.

Jaume, S.C. and L.R. Sykes, Evolving Towards a Critical Point: A Review of Accelerating Seismic  
Moment/Energy Release Prior to Large and Great Earthquakes, Pure Appl. Geophys., 155, 279, 1999.

# Corpus - Solutions



# Corpus - Solutions



# Corpus - Result

## ■ Size

- 1.2 M documents (2.7 M cited)
- 16 M references
- 29 M in-text citation markers

## ■ Scope

- 1991–2018 (current: 2022)
- physics (63%), maths (23%), CS (11%), other (3%)

## ■ Reference matching

- 53% by parsing + matching
- 28% by DOI
- 19% by arXiv ID

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# Corpus - Result

Data set	# Docs	Cit. markers	Disciplines	Full text	Linked
ACL-ARC [2]	11 k	no	comp. ling.	PDF	✗
ACL-AAN [3]	18 k	no	comp. ling.	PDF	✗
Scholarly Dataset 2 [4]	100 k	no	CS	PDF	✗
CiteSeerX [5] / RefSeer [6]	1 M	ambiguous	mixed	400 char excerpts	✗
PMC OAS [7]	2.3 M	exact	biomedical	XML	mixed <sup>a</sup>
arXiv CS [8]	90 k	exact	CS	text	✓
<b>unarXive</b> [1]	1.2 M	exact	phys., maths, CS	text	✓

<sup>a</sup> No citation network due to mixed set of IDs (PubMed, MEDLINE, DOI) [9].

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# Corpus - Result (2022)

Data Set	Source Data	Format	Citation Network <sup>a</sup>				Purpose
			general	compare	# Docs	Disciplines	
CORE [10]	multiple	PDF	0%	-	>100 M	various	general NLP
S2ORC (PDF) [11]	multiple	PDF	69.4%	-	12 M	various	general NLP
unarXive 2020 [1]	arXiv.org	L <small>A</small> T <small>E</small> X	42.6%	42.6%	1.2 M	phys., maths, CS	general NLP
S2ORC (L <small>A</small> T <small>E</small> X) [11]	arXiv.org	L <small>A</small> T <small>E</small> X	31.1%	31.1%	1.5 M	phys., maths, CS	general NLP
arXMLiv [12]	arXiv.org	L <small>A</small> T <small>E</small> X	0%	0%	1.6 M	phys., maths, CS	maths linguistics
SciXGen [13]	arXiv.org	L <small>A</small> T <small>E</small> X	41.6%	-	205 k	CS	text generation
PMC-OAS [7]	PubMed	XML	mixed <sup>b</sup>	-	3.3 M	biomedical	not NLP specific
unarXive 2022 [14]	arXiv.org	L <small>A</small> T <small>E</small> X	44.4%	44.4%	1.9 M	phys., maths, CS	general NLP

<sup>a</sup> “general”: whole data set; not directly comparable. “compare”: arXiv.org data from 1991–2020; directly comparable.

<sup>b</sup> No citation network due to mixed set of IDs (PubMed, MEDLINE, DOI) [9].

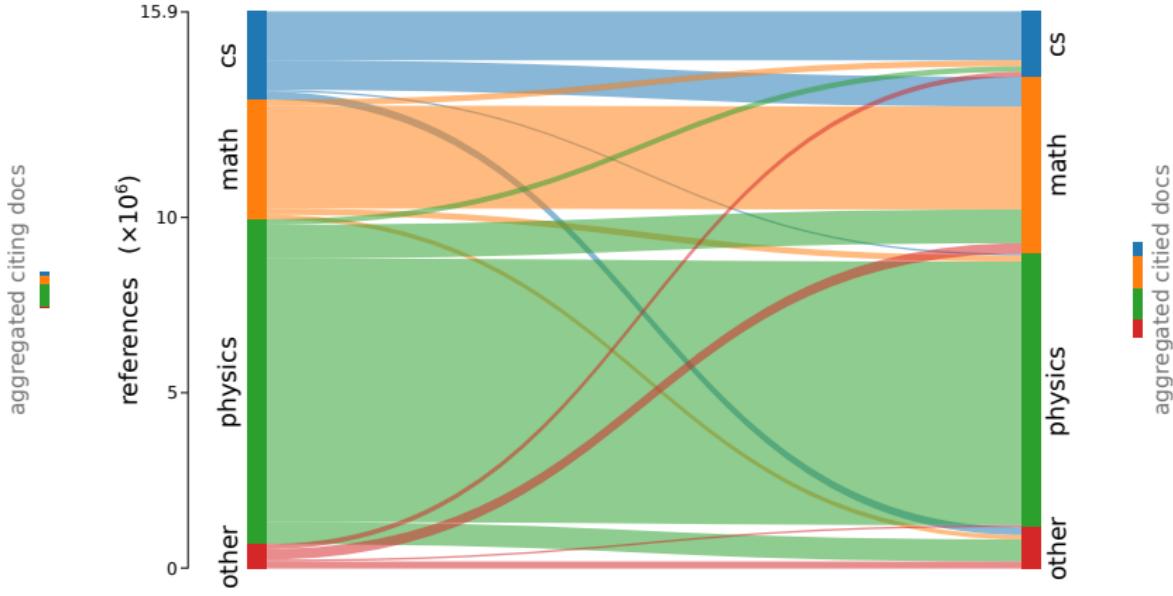
# Corpus - Link Correctness

Table: Link correctness (n = 300)

Confidence level	Method <sup>a</sup>	Lower limit	Upper limit
0.99	Wilson	0.9613	0.9975
	Jeffreys	0.9666	0.9983
0.95	Wilson	0.9710	0.9966
	Jeffreys	0.9736	0.9972

<sup>a</sup> Confidence interval given as Wilson score interval and Jeffreys interval [15].

# Corpus - Citation Flow



# Corpus - Conclusion

## ■ Advancements

- More extensive
  - single domain vs multi domain
  - 90 k vs 1.2 M / 2022: 1.6 M vs 1.9 M
- More complete, high quality citation network
  - 13.3% increase in matched references
- Less noise due to  $\text{\LaTeX}$  as source
- Novel types of analyses possible

## ■ Foundation for further studies

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**Cit. Netw. & Cross-Ling.**

# Citation Network - Digest

## ■ Research gap

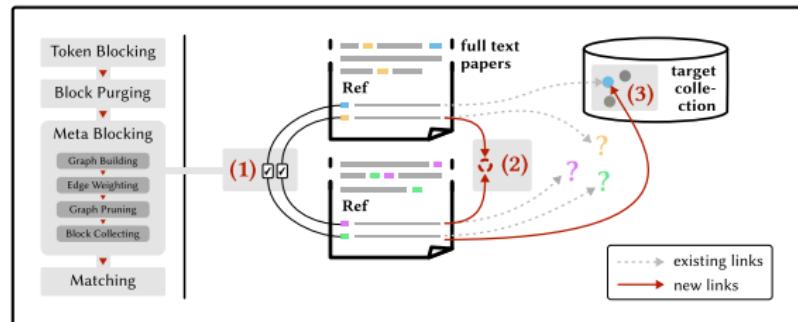
- Reference linking coverage
- Reliance on target data set

## ■ Approach

- Use unarXive data
- Improved reference parsing pipeline
- Blocking approach used within set of references

## ■ Results

- 2% increase in base matching success
- Manifold increase in bibliographic coupling matches



**ULITE'22 [16]**

**JCDL'23 [14]**

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# Cross-Linguality - Digest

## ■ Research gap

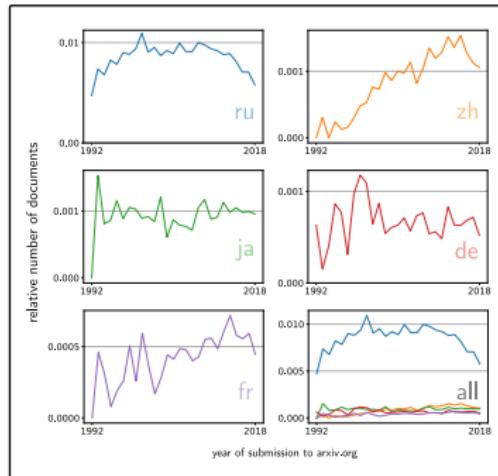
- Restriction of existing work to English
- Limited scale of existing studies

## ■ Approach

- Use unarXive data
- Document language from raw reference strings
- Temporal and geographic analyses

## ■ Results

- Reliable method for identification
- Largest study so far (<1k → >1M)
- Identification of trends and challenges



ICADL'20 [17]

IJDL'22 [18]

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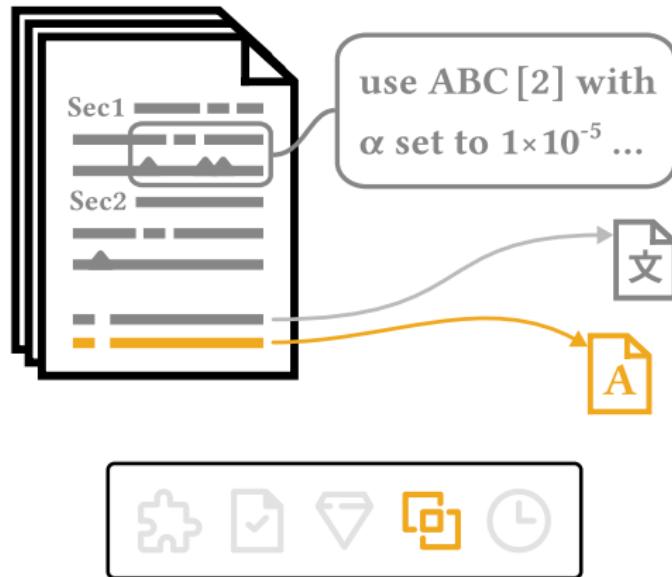
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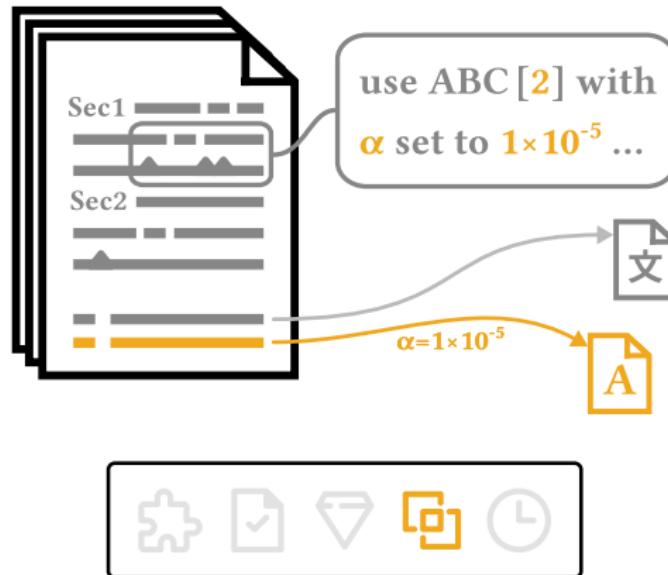
References

# **Parameters**

# Parameters



# Parameters



# Parameters - Digest

## ■ Research gap

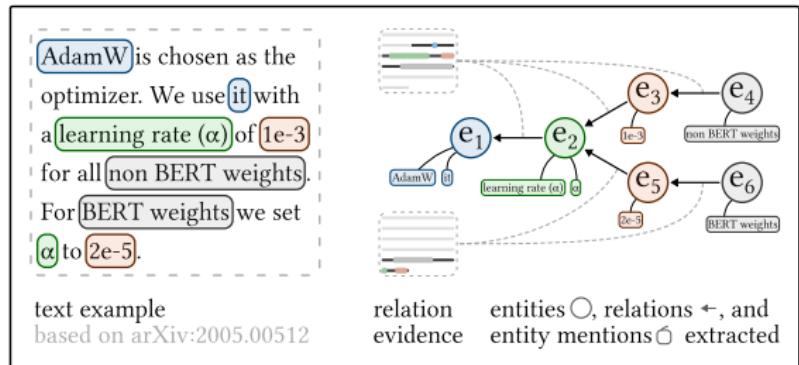
- Important information not considered
- Lack of link granularity
- No formalization/approaches

## ■ Approach

- Task formalization
- Data annotation (data from unarXive)
- Two lines of approaches
  - BERT based model approach
  - LLM based approach

## ■ Results

- Novel task, novel data
- Improvements over SOTA baselines



ECIR'24 [19]

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# Parameters - Task Definition

## ■ Goal

- Automatically extract parameter information from paper text

## ■ Motivation

- Reproducibility indication [20], automation [21]
- Uncover conventions and trends
- More fine-grained paper representations (similarity measures, recommendation, search)

## ■ Task Type

- (Named) Entity Recognition, Relation Extraction

For ADAM, we set  $\beta_2 = 0.999$

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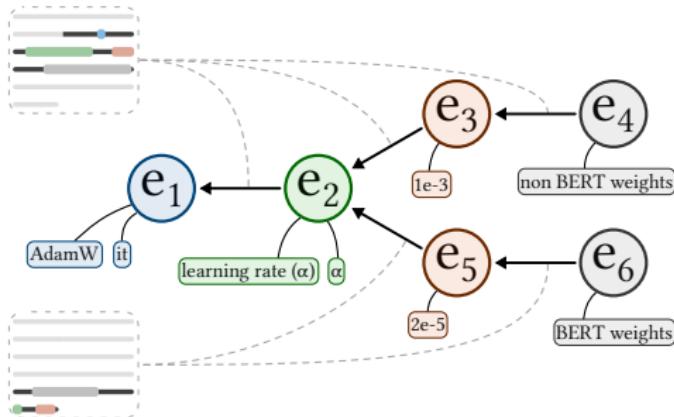
# Parameters - Scope & Annotation Scheme

- 4 entity classes
  - (1) research **artifact**: model, method, data set, ...
  - descriptions of how authors use the artifacts
  - (2) **parameter** ( $\alpha$ , learning rate, k, ...)
  - (3) **value** (1e-3, five,  $\frac{1}{3}$ , ...)
  - (4) **context** (for fine-tuning, during grid search, ...)
- 1 relation type
- out of scope
  - measurements ("We obtain an AUC value of 0.75")

# Scope & Annotation Scheme

AdamW is chosen as the optimizer. We use it with a learning rate ( $\alpha$ ) of  $1e-3$  for all non BERT weights. For BERT weights we set  $\alpha$  to  $2e-5$ .

text example  
based on arXiv:2005.00512



relation entities  $\circlearrowleft$ , relations  $\leftarrow$ , and entity mentions  $\circlearrowright$  extracted

# Parameters - Data

- Annotation approach
  - Guidelines based on ACL RD-TEC guidelines [22]
  - Paragraph level, whole papers
- Extent
  - 444 paragraphs
  - 1,971 entities
    - (1,134 a, 131 p, 662 v, 44 c)
  - 614 relations
- IAA
  - 0.867 for entities
  - 0.737 for relations

The screenshot shows two main sections of the RD-TEC guidelines:

- Annotation Guidelines:** This section contains detailed instructions for annotation, including:
  - General:** Describes the scope of annotation (whole paper) and the types of annotations (e.g., author, title, abstract).
  - Entity Types:** Lists entity types such as "Author", "Title", "Abstract", "Text", "Section", "Figure", "Table", and "Equation".
  - Relationship Types:** Lists relationship types such as "Authorship", "Title", "Text", "Section", "Figure", "Table", and "Equation".
  - Annotations:** Provides examples of how to annotate specific parts of a paper.
- Research Article:** This section provides specific guidelines for annotating research articles, covering:
  - General:** Annotations for titles, abstracts, and sections like "Introduction", "Methods", "Results", and "Conclusion".
  - Entity Types:** Annotations for authors, titles, abstracts, and sections.
  - Relationship Types:** Annotations for relationships between entities, such as "Authorship" and "Citation".
  - Annotations:** Examples of how to annotate specific parts of a research article.

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# Parameters - Data

- Annotation approach
  - Guidelines based on ACL RD-TEC guidelines [22]
  - Paragraph level, whole papers
- Extent
  - 444 paragraphs
  - 1,971 entities
    - (1,134 a, 131 p, 662 v, 44 c)
  - 614 relations
- IAA
  - 0.867 for entities
  - 0.737 for relations

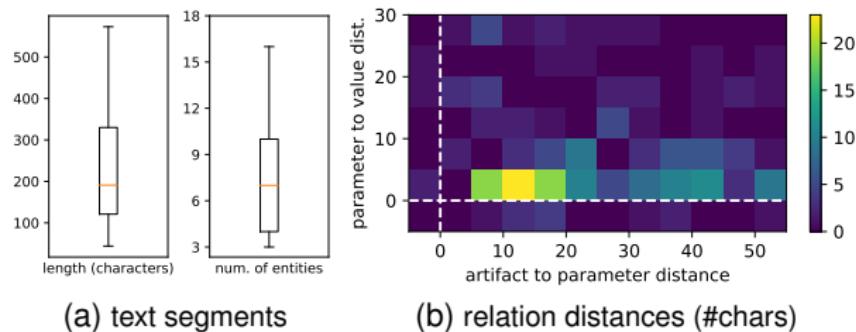


Figure: Observations of initial annotation round

# Parameters - Related Work: Fine-tuned models

- SciERC dataset
  - SCIIE [23]
  - PL-Marker [24]
  - → overlap
- SciREX dataset
  - TempGen [25] (only RE)
- SemEval 2022 (math symb. to descr.)
  - JBUU-CCLab [26]
  - AIFB [27]
- SemEval 2021 (measurements)
  - LIORI [28]
  - → mention patterns

We evaluate our model on the task of **question answering** using

#### Section : Dataset

**SQuAD** is a **machine comprehension** dataset on a large set of **Wikipedia articles** , ..... Two metrics are used to evaluate models: **Exact Match ( EM )** and a softer metric , **F1 score** .....

#### Section: Model Details .

... Each paragraph and question are tokenized by a regular - expression - based word tokenizer ( **PTB Tokenizer** ) and fed into the model .  
....

#### Section : Results .

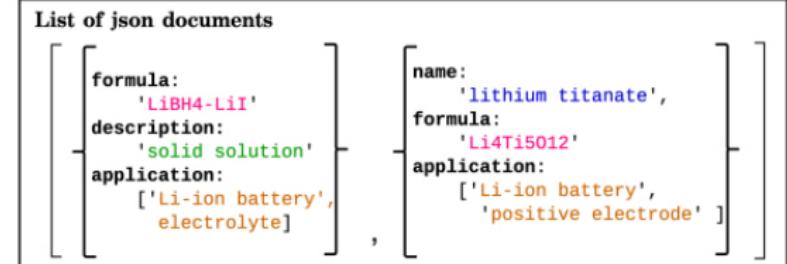
The results of our model and competing approaches on the hidden test are summarized in Table [ reference ]. **BiDAF { ensemble }** achieves an **EM** score of 73.3 and an **F1** score of 81.1, outperforming all previous approaches .

# Parameters - Related Work: LLMs

- Medical science [29]
  - singular values
  - lists
- Material science [30–32]
  - singular values
  - lists
  - complex [32] (see right)

Note: all of the above evaluate on GPT models only.

Document: The charge and discharge performance of an all-solid-state lithium battery with the LiBH4-LiI solid solution as an electrolyte is reported. Lithium titanate (Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub>) was used as the positive electrode and...



# Parameters - Approach

## ■ Fine-tuned, supervised

- PL-Marker (SciERC SOTA)
- Mention pattern aware RE (ours)

## ■ LLM, zero-/few-shot

- 6 models
- JSON approach (MatSci)
- YAML approach (ours)

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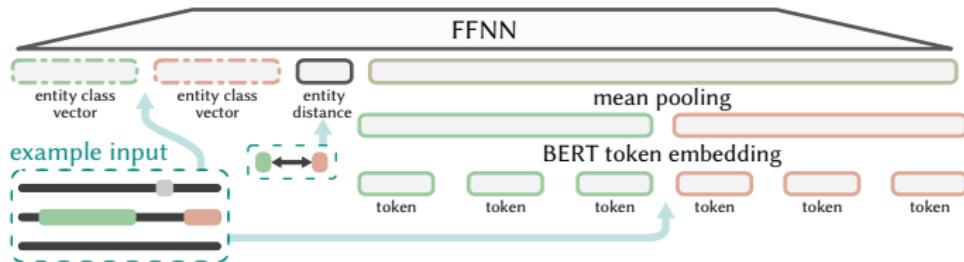
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# Parameters - Methods: Fine-tuned models

- Based on PL-Marker
- New RE module
- Include entity class emb. + distance in model input



# Parameters - Methods: LLMs

- Test various prompting techniques
  - Multi-stage
  - In-text annotation
  - Data serialization format ✓
- Compare 6 models
- Base prompt + tuning for each
- Few-shot only with Vicuna<sub>16k</sub>

Model	Variant	Size
WizardLM [33]	WizardLM-13B-V1.1	13 B
Vicuna <sub>4k</sub> [34]	vicuna-13b-v1.3	13 B
Vicuna <sub>16k</sub> [34]	vicuna-13b-v1.5-16k	13 B
Falcon [35]	falcon-40b-instruct	40 B
GALACTICA [36]	galactica-120b	120 B
GPT-3.5 [37]	text-davinci-003	175 B

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# Parameters - Methods: LLMs

In the context of machine learning and related fields, what (if any) are the entities (datasets, models, methods, loss functions, regularization techniques) mentioned in the LaTeX Input Text below? What (if any) are their parameters and values?

```
[LaTeX Input Text start]
We use AdamW with a learning rate ($\alpha$) of 1e-3 for /* [...] */
[LaTeX Input Text end]
```

Answer in the following YAML format.

Format:

```
---
text_contains_entities: true/false
entities:
  - entity<N>:
    id: e<N>
    name: "<entity name>"
    type: dataset/model/method/loss function/regularization technique
    has_parameters: true/false
    parameters:
      - parameter<M>:
        id: p<N.M>
/* [...] */
...
```

Only include entities that are of type dataset, model, method, loss function, or regularization technique. Do not output entities that are of another type. Do not include entities of type task, metric, library, software, or API.

Only produce output in the YAML format specified above. Output no additional text.

Output:

# Parameters - Experiments: Fine-tuned models

5-fold cross-validation, stratified sampling

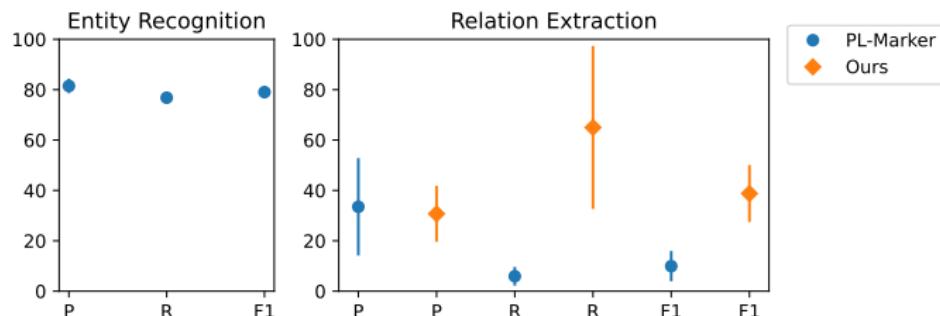


Table: Ablation study results (model inputs are: T = BERT token embeddings, C = entity class embeddings, D = entity distance)

Used	P [%]	R [%]	F <sub>1</sub> [%]
TCD	15.5	8.8	11.1
T <sub>CD</sub>	16.6	29.8	19.6
T <sub>C</sub> D	26.5	65.0	35.5
<b>TCD</b>	<b>30.7</b>	<b>65.0</b>	<b>38.8</b>

# Parameters - Experiments: LLMs

Zero-shot		Entity Recognition			Relation Extraction		
Model	Output	P [%]	R [%]	F <sub>1</sub> [%]	P [%]	R [%]	F <sub>1</sub> [%]
WizardLM	JSON	6.9	11.3	8.6	0.1	0.8	0.1
	YAML	9.7	35.6	15.3 <sub>△+6.7</sub>	0.1	1.5	0.1 <sub>△+0.0</sub>
Vicuna <sub>4k</sub>	JSON	15.1	9.3	11.5	0.7	3.8	1.2
	YAML	17.3	31.5	22.3 <sub>△+10.8</sub>	0.0	0.8	0.1 <sub>△-1.1</sub>
Falcon	JSON	<b>37.1</b>	5.9	10.2	0.0	0.0	0.0
	YAML	32.7	14.2	19.8 <sub>△+9.6</sub>	0.0	0.0	0.0 <sub>△+0.0</sub>
GALACTICA	JSON	25.9	15.7	19.5	0.1	2.3	0.3
	YAML	23.1	19.5	21.1 <sub>△+1.6</sub>	0.0	0.8	0.1 <sub>△-0.2</sub>
GPT-3.5	JSON	27.9	<b>42.8</b>	33.8	5.4	10.7	7.2
	YAML	<u>34.0</u>	<u>41.7</u>	<u>37.4<sub>△+3.6</sub></u>	<u>5.8</u>	<u>12.2</u>	<u>7.8<sub>△+0.6</sub></u>
5-shot		Entity Recognition			Relation Extraction		
Vicuna <sub>16k</sub>	JSON	34.4	<u>46.7</u>	39.6	0.8	4.6	1.3
	YAML	<b>43.9</b>	<b>44.1</b>	<u>44.0<sub>△+0.4</sub></u>	<b>4.5</b>	<b>9.9</b>	<b>6.1<sub>△+4.8</sub></b>

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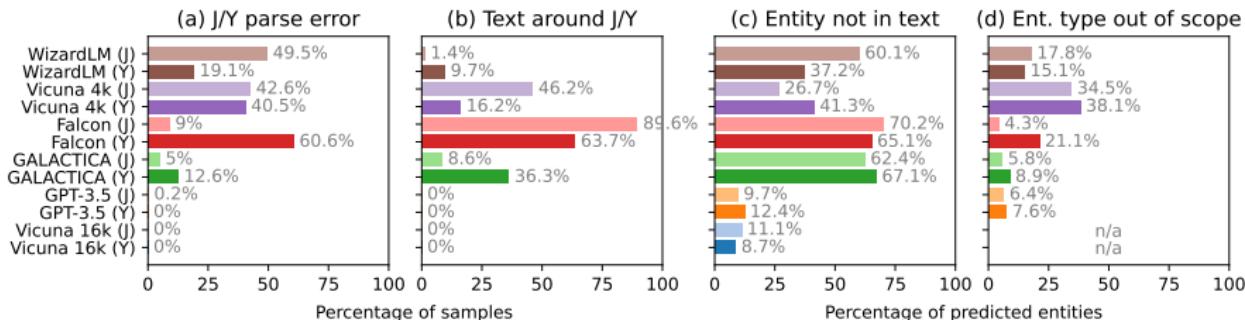
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# Parameters - Experiments: LLMs



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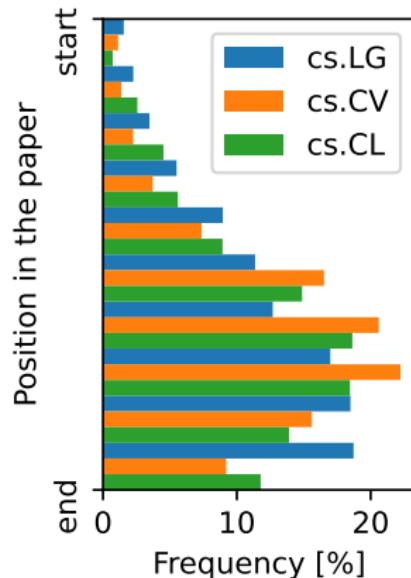
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# Parameters - Experiments: Application

- Apply best model (BERT based) on 15k paper sample
- Parameters information given in
  - 36% of ML papers
  - 42% of CV papers
  - 36% of CL papers
  - 7% of DL papers
- Distribution towards second half of paper across disciplines



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# Parameters - Discussion

- Applicable on large scale
- LLMs not on par with BERT based model
- **Advancements**
  - Task formalization (scope, data scheme, annotation guidelines)
  - High quality manually annotated data set
  - BERT model based approach
    - 29%  $F_1$  increase for RE
  - LLM approach
    - avg. 5.5%  $F_1$  increase for NER
    - consistent across all LLMs

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# **Conclusion**

# Overall Conclusion



## Research Objective

Develop methods for generating high-quality scholarly data.

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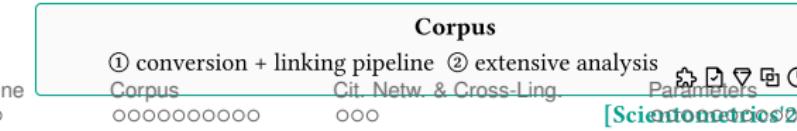
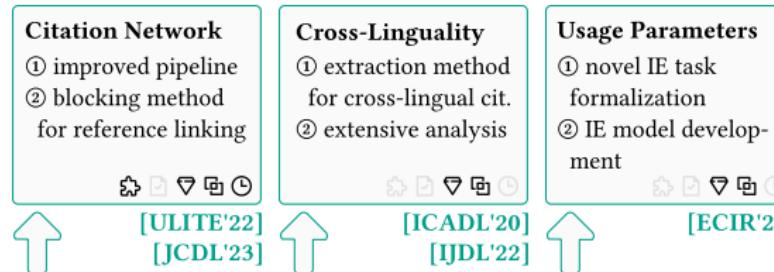
# Overall Conclusion



## Research Objective

Develop methods for generating high-quality scholarly data.

like this:



# Overall Conclusion



## Research Objective

Develop methods for generating high-quality scholarly data.

- Scholarly data from source formats
- Joint handling of docs & references
- Identifier aware references parsing
- Intra references clustering & matching
- Extraction of non-English content
- Identification of cross-lingual references from raw references
- Extraction of usage parameters from full text
- Mention pattern aware relation extraction

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# Overall Conclusion

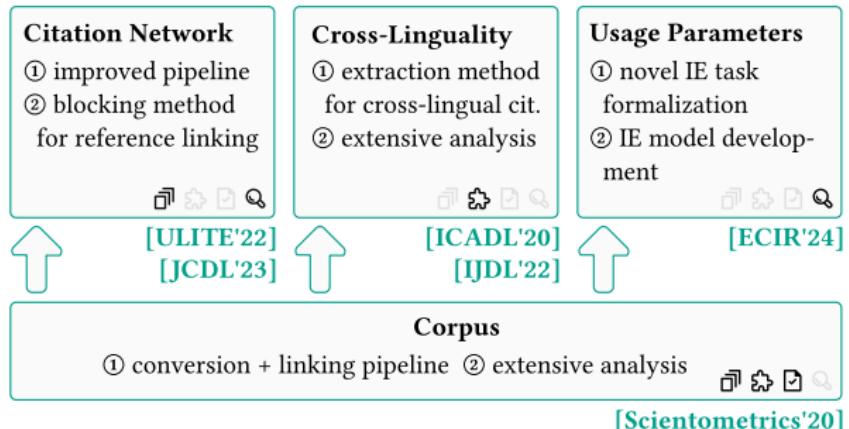
## ■ Big Picture

- Corpus creation method
- Advances in three focus areas
  - Citation Network
  - Cross-Linguality
  - Usage Parameters

## ■ Improved

- Volume
- Completeness
- Correctness
- Granularity

## ■ Impact on research community



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# Impact

Adoption by the research community.

## ■ Methodology

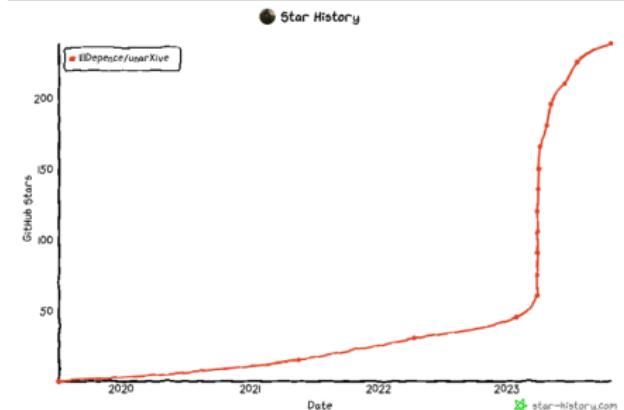
- Document Parsing Methodology [11]

## ■ Model dev/eval

- Citation Recommendation [38] ([39, 40])
- Citation Analysis [41, 42] ([17, 18])
- Document Retrieval [43]
- Researcher Profile Embeddings [44]
- Reference Linking ([16])

## ■ Dataset extension

- Link Prediction ([45])
- NER+RE ([19])



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References

**Thank You ☺**

**Questions?**

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Motivation  
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Cit. Netw. & Cross-Ling.  
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Parameters  
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Conclusion  
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References

# References VII

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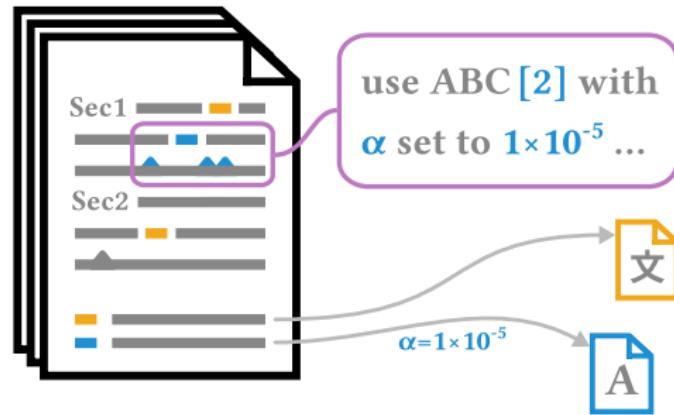
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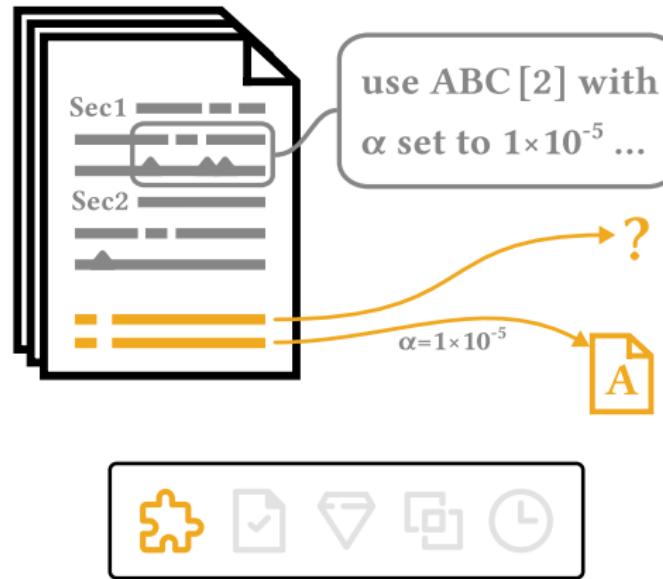
References

# **Extra Slides**

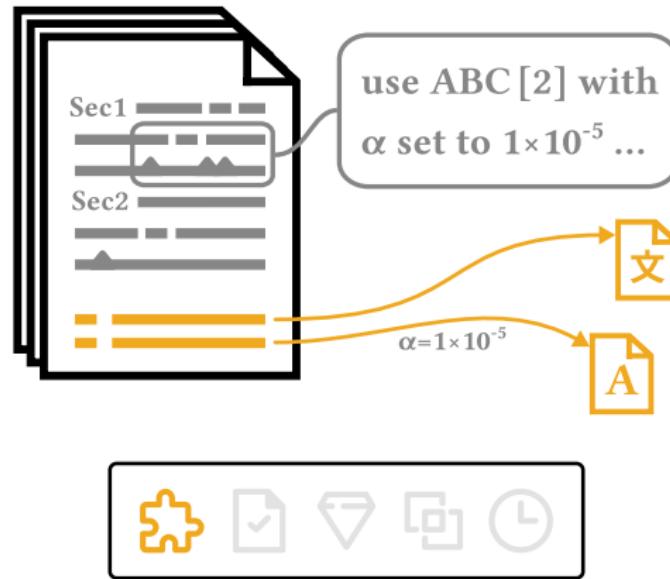
# Quality Aspects



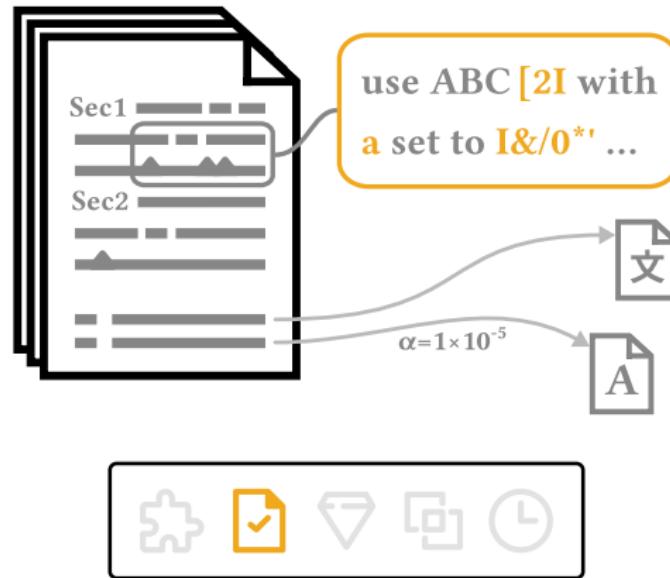
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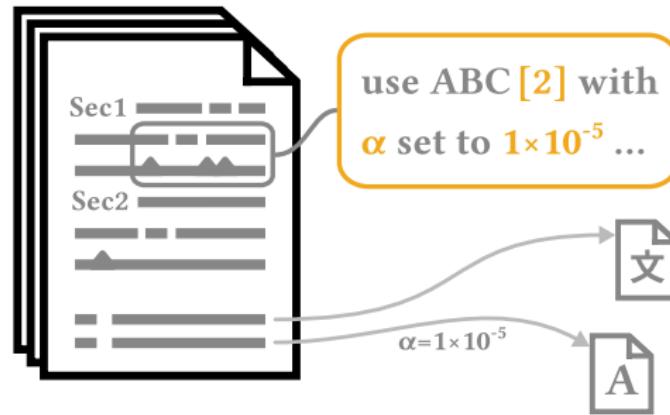
# Quality Aspects



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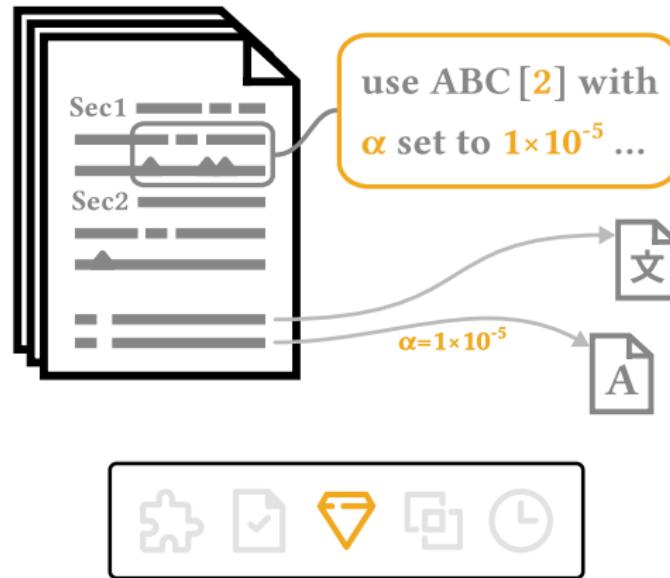
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# Quality Aspects



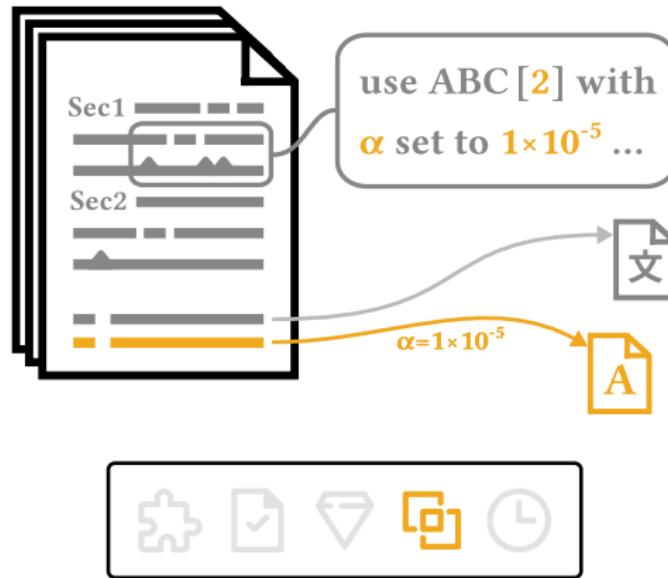
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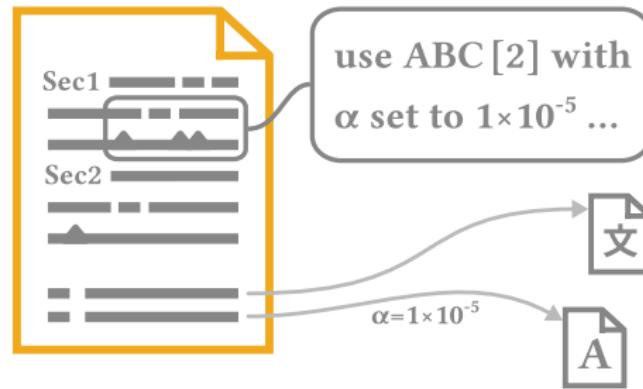
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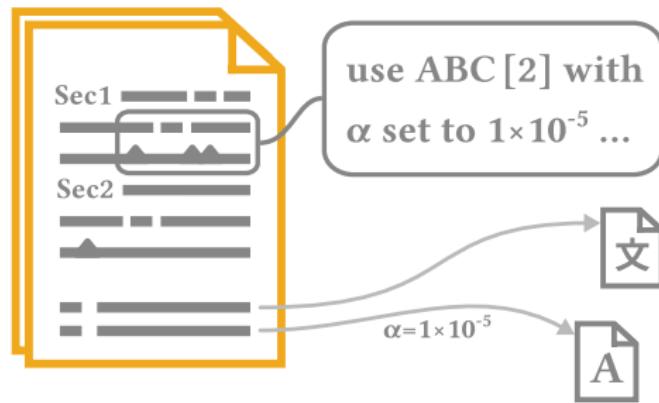
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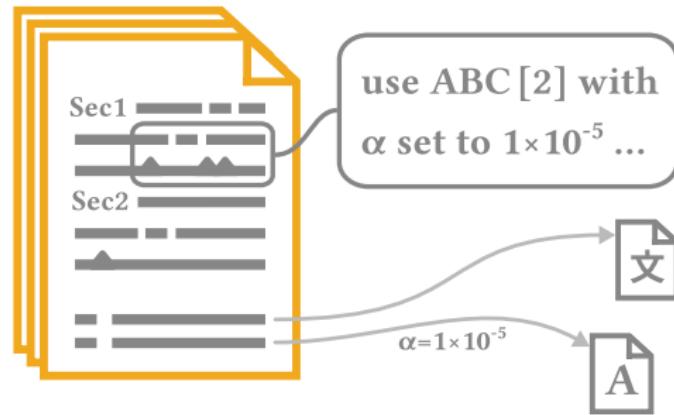
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# Quality Aspects



# Quality Aspects



# Corpus - Stats

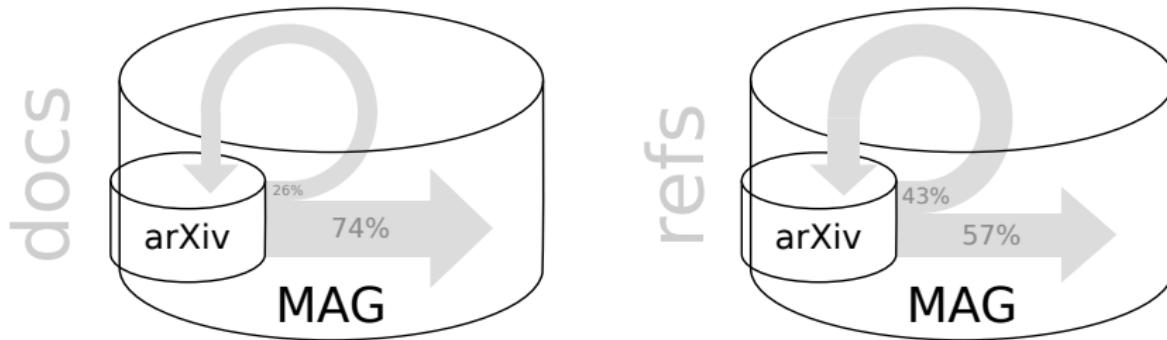
	citing documents		references		cited documents
		outgoing		incoming	
<i>full data set:</i>	<b>1,043,126</b>	15,954,664		<b>15,954,664</b>	<b>2,746,288</b>
full text	1,043,126	15,954,664		7,181,576	736,597
linked to MAG	994,351	15,846,351		15,954,664	2,746,288
<i>by discipline:</i>					
physics	662,894	9,300,576		7,827,072	921,852
mathematics	237,422	3,426,117		5,062,033	906,301
computer science	111,694	2,526,656		1,876,401	425,860
other	31,116	701,315		1,189,158	492,275

**data:** <http://doi.org/10.5281/zenodo.3385851>

**code:** <https://github.com/IllDepence/unarXive>



## Corpus - Citation Flow



# Corpus - Reference Composition

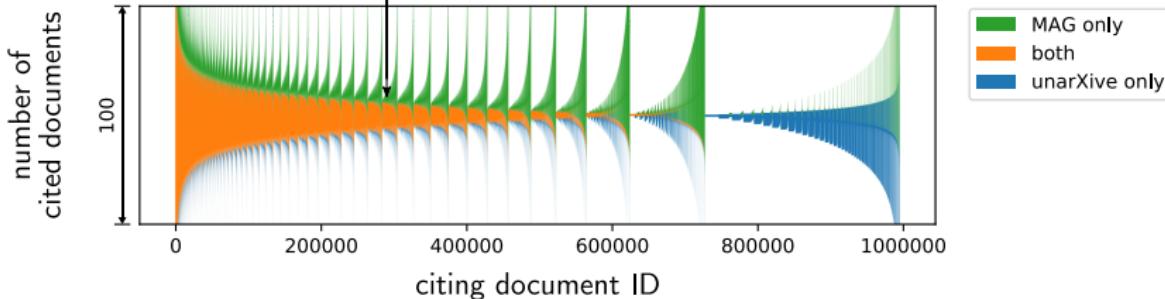
Exemplary visualization  
of a single data point  
on the x-axis.

document #288983

[...]

## References

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# Corpus - Target Sec. Specific Refs

	Discipline <sup>a</sup>	Count	Normalization factor	Normalized ratio (%)
<b>Citing</b>	Mathematics	298,009	4.66	8.70
	CS	9,123	6.31	0.36
	Physics	30,593	1.72	0.33
<b>Cited</b>	Mathematics	313,651	3.15	6.20
	CS	12,179	8.50	0.65
	Physics	31,087	2.04	0.40
<b>Pairs</b>	<u>Math<sup>†</sup>→Math<sup>‡</sup></u>	200,859	5.41	6.81
	<u>Math<sup>†</sup>→CS</u>	5,134	92.13	2.96
	<u>Math<sup>†</sup>→Phys</u>	3,114	89.88	1.75
	<u>CS→Math<sup>‡</sup></u>	3,456	18.82	0.41
	<u>Phys→Math<sup>‡</sup></u>	3,859	16.49	0.40
	<u>CS→CS</u>	2,500	11.38	0.18
	<u>Phys→Phys</u>	10,374	2.12	0.14
	<u>CS→Phys</u>	50	307.16	0.10
	<u>Phys→CS</u>	137	101.40	0.09

<sup>a</sup>  $\dagger$ : Mathematics citing document,  $\ddagger$ : Mathematics cited document, X→X: Citing and cited document are from the same discipline).



# Parameters - Motivation

Jurgens, D. et al. Measuring the Evolution of a Scientific Field through Citation Frames. *Transactions of the Association for Computational Linguistics* 6, 391–406 (2018)

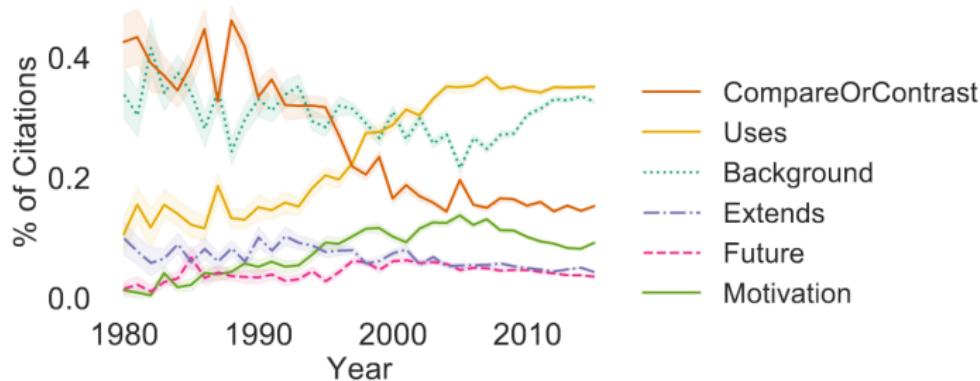


Figure 5: Changes in the average citation frame in ACL papers reveals a continued decline in the percentage of COMPARISON OR CONTRAST and increase in USES citations. The increase in BACKGROUND citations circa 2010 marks the start of the era of unlimited references in ACL conferences. Shaded regions show bootstrapped 95% confidence intervals.



# Parameters - Motivation

The screenshot shows the homepage of the Dagstuhl Artifacts Series (DARTS) website. At the top, there is a navigation bar with links to THE INSTITUTE, SEMINARS, PUBLISHING, DBLP, GUEST INFORMATION, and CONTACT. On the right side of the navigation bar is a search bar with a magnifying glass icon and language links for EN and DE. Below the navigation bar is a logo for "DAGSTUHL ARTIFACTS SERIES" featuring a stylized yellow 'W' icon.

## Dagstuhl Artifacts Series (DARTS)

The main content area features several tabs: GENERAL (selected), EDITORIAL BOARD, SELECTION/REVIEW, AUTHOR INSTRUCTIONS, EDITOR INSTRUCTIONS, and RECENTLY PUBLISHED. Below these tabs is a paragraph describing the DARTS series, stating it publishes evaluated research data and artifacts in all areas of computer science. It defines an artifact as any kind of content related to computer science research, such as experimental data, source code, virtual machines containing a complete setup, test suites, or tools. It contrasts this with existing repositories like Zenodo or figshare, noting that DARTS focuses on artifacts that underwent an evaluation process before publication.

An artifact should be related to a research paper (which does not necessarily have to be published within a series of Dagstuhl Publishing) but which should be clearly citable, e.g., by a DOI and should help to verify the repeatability and correctness of the experiments/implementations described in the related paper.

The series is organized as a periodical consisting of one volume per year. Each volume can consist of several issues. Thereby, DARTS currently focuses on special issues that are related to a conference.

**Publications**  
DARTS webportal: Archive of all published DARTS volumes.  
DARTS @ dblp

**Aims and Scope**  
The DARTS series aims at the provision of a publication venue for evaluated research data and artifacts. An artifact can be any kind of content related to computer science research, e.g., experimental data, source code, virtual machines containing a complete setup, test suites, or tools. In contrast to existing repositories for research data and artifacts, DARTS focuses on artifacts that underwent an evaluation process before their publication.

The scope of DARTS covers all areas of computer science.

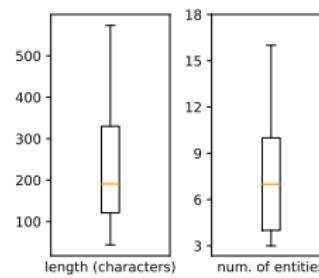
**Open Access Policy**  
Artifacts in DARTS are peer-reviewed and are published electronically according to the principles of open access, i.e., they are available online and free of charge.

**License**  
Each artifact description is published under a Creative Commons CC BY license (<http://creativecommons.org/licenses/by/4.0/>). The actual artifact is published under a Open Source license to be found in the artifact description. The metadata provided by Dagstuhl Publishing on its webpages, as well as their export formats (such as XML or BibTeX) available at our website, is released under the CC0 1.0 Public Domain Dedication license (<https://creativecommons.org/publicdomain>)

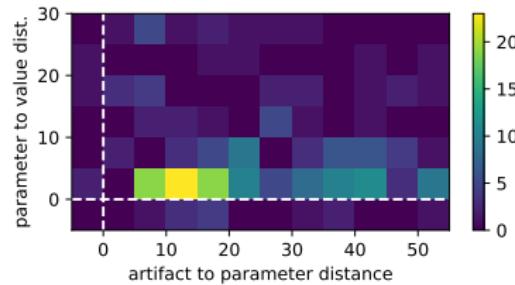


# Parameters - Data

- Two annotation rounds
- Initial (pre-filtered text, exploratory, to fine-adjust scheme)
  - 151 text segments
  - 1,345 entities
  - 1,110 relations
- Main (full papers, eval data)
  - 444 paragraphs
  - 1,971 entities  
(1,134 a, 131 p, 662 v, 44 c)
  - 614 relations
- IAA
  - 0.867 for entities
  - 0.737 for relations



(a) text segments



(b) relation distances (#chars)

Figure: Observations of initial annotation round



# Publications - primary

Chap.	Venue	Year	Type	Length	Author Position	Venue Rating	Ref.
3	Scientometrics	2020	Journal	Full	1 of 2	SJR Q1	[1]
4	JCDL	2022	Workshop	Full	1 of 3	Core A*	[16]
	JCDL	2023	Conference	Short	1 of 3	Core A*	[14]
5	ICADL	2020	Conference	Full	1 of 2	Core A	[17]
	IJDL	2022	Journal	Full	1 of 3	SJR Q2	[18]
6	(ECIR)	*	Conference	Full	1 of 4	Core A	[19]

Venue ranks from Core<sup>1</sup> (conferences) and SJR<sup>2</sup> (journals).<sup>3</sup>

<sup>1</sup>See <http://portal.core.edu.au/conf-ranks/> (last accessed 2023-10-12).

<sup>2</sup>See <https://www.scimagojr.com/> (last accessed 2023-10-12).

<sup>3</sup>Ratings for publication year or, if not listed, most up-to-date ranking. Workshops ranks are that of the hosting conference.



## Publications - secondary

Venue	Year	Type	Length	Author Position	Venue	Ref.
ECIR	2019	Workshop	Full	1 of 2	Core A	[39]
ECIR	2020	Conference	Full	1 of 3	Core A	[47]
NAACL	2021	Workshop	Short	3 of 4	Core A	[48]
AAAI	2022	Workshop	Full	2 of 3	Core A*	[49]
JCDL	2022	Conference	Full	3 of 3	Core A*	[50]
JCDL	2023	Conference	Short	1 of 3	Core A*	[45]

Additional publications (co-)authored leading up to and during the research period which are not a direct part of the dissertation, but nevertheless informed the overall research trajectory. Especially [39] and [48], which constitute the results of the master's thesis preceding the doctoral research period, paved the way for the dissertation.



# Limitations

- **Corpus**

- $\text{\LaTeX}$  required (no humanities)

- **Cit. Netw.**

- Blocking method scalability

- **Cross.-Ling.**

- Single “direction”
  - Dependency on author notation

- **Parameters**

- IE from text, not tables, code, etc.
  - ML specific
  - English only

