Searching the ACL Anthology with Math Formulas and Text

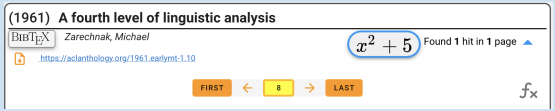
Bryan Amador, Matt Langsenkamp, Abhisek Dey, Ayush Kumar Shah and Richard Zanibbi
Rochester Institute of Technology, USA

MathDeck Overview

MathDeck is a user-friendly search engine for formulas and text in PDF. The system supports formula extraction, search, editing with LaTeX, handwriting and visual operations, and formula annotation and export.

Search Interface Features

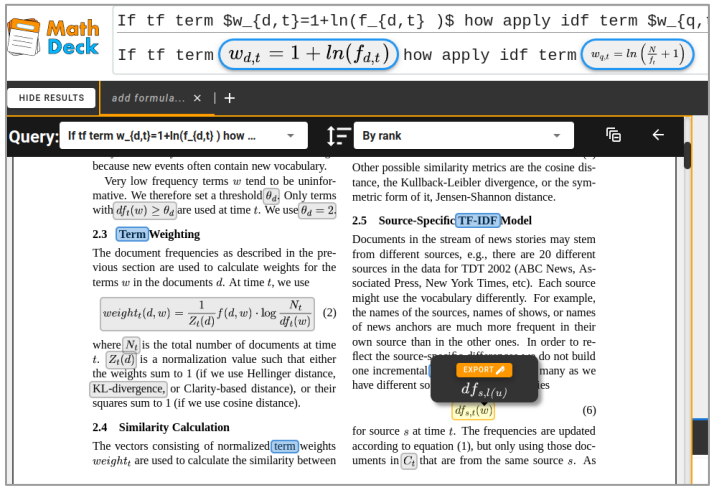
- **Queries** combine formulas + text
- **Highlights** matched formulas + text in PDF pages
- **Import** formulas as 'chips' for search, editing, reuse
- **Cards** add titles and descriptions for formula 'chips'
- **Decks** collect searchable cards + autocompletion
- **Formula editor** with LaTeX + visual operations [1]



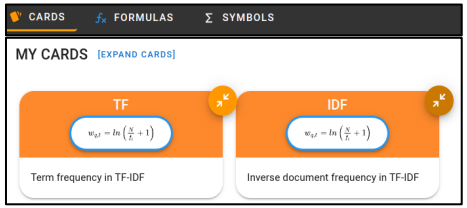
Top of a Document Hit Summary. Includes BibTeX button, ACL link & view formulas button (f_x)

Collection: ACL Anthology PDFs

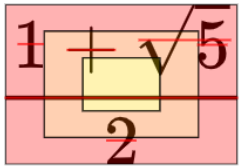
- 11,021 PDFs from 1952-2005 with BibTeX data
- 463,050 extracted formulas
- **Formula Extraction:** ScanSSD-XYc [2] and SymbolScraper [3] extract symbols and formula locations; QDGGA [4] parses images into LaTeX
- **Text:** SymbolScraper provides word locations



Example Search Result. Formula hits are shown in yellow, text hits in blue, and additional formulas in gray.



Example Card Deck Showing TF and IDF



Example PHOC: 3 Nested Rectangles ('R3' Level 3). Red lines: symbol 'locations'

PDF Retrieval: Formula PHOC + BM25

PDFs ranked by best-scoring page. Ranking combines **Pyramidal Histogram of Character (PHOC)** formula retrieval with BM25 for text, in *OpenSearch*

Retrieval Model Summary

- **Formula PHOC:** spatially-augmented bag of words [5]: binary vectors for symbols in overlapping regions. **R10** with concentric rectangles used (55 regions/bits)
- **Formula similarity:** cosine similarity over PHOC vectors (using fast bitwise operations)

$$cos(\mathbf{a},\mathbf{b}) \overset{rank}{=} bcos(\mathbf{a},\mathbf{b}) = \frac{1}{\sqrt{|\mathbf{b}|_1}} |\mathbf{a} \wedge \mathbf{b}|_1$$

- **Documents Ranked by Highest Scoring Page.** Page score is **BM25** text score + **3 times** the **sum** of the top match for each query formula on a page

ARQMath-2 [6] Formula Retrieval Task

R10 PHOC model competitive despite being a sparse 'spatial' bag-of-words model without unification of symbols

System	NDCG'	MAP'	P'@10
R10-PHOC	0.5136	0.3005	0.4810
Approach0	0.6520	0.4710	0.6120
TangentCFT	0.6300	0.4830	0.6620

[1] Gavin Nishizawa, Jennifer Liu, Yancarlos Diaz, Abishai Dmello, Wei Zhong, and R. Zanibbi. 2020. **MathSeer: A math-aware search interface with intuitive formula editing, reuse, and lookup**. CHI 2020.
[2] Abhisek Dey and Richard Zanibbi. 2021. **ScanSSD-XYc: Faster detection for math formulas**. ICDAR 2021.
[3] Ayush Kumar Shah, Abhisek Dey, and Richard Zanibbi. 2021. **A math formula extraction and evaluation framework for PDF documents**. ICDAR 2021.
[4] Mahshad Mahdavi and Richard Zanibbi. 2020. **Visual parsing with query-driven global graph attention (QD GGA): Preliminary results for handwritten math formula recognition**. CVPR Work. 2020.
[5] Matt Langsenkamp, Behrooz Mansouri, and Richard Zanibbi. **Expanding spatial regions and incorporating IDF for PHOC-based math formula retrieval at ARQMath-3**. CLEF 2022.
[6] Behrooz Mansouri, Vít Novotný, Anurag Agarwal, Douglas W. Oard, and Richard Zanibbi. 2022. **Overview of ARQMath-3 (2022): Third CLEF lab on Answer Retrieval for Questions on Math**. CLEF 2022.

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