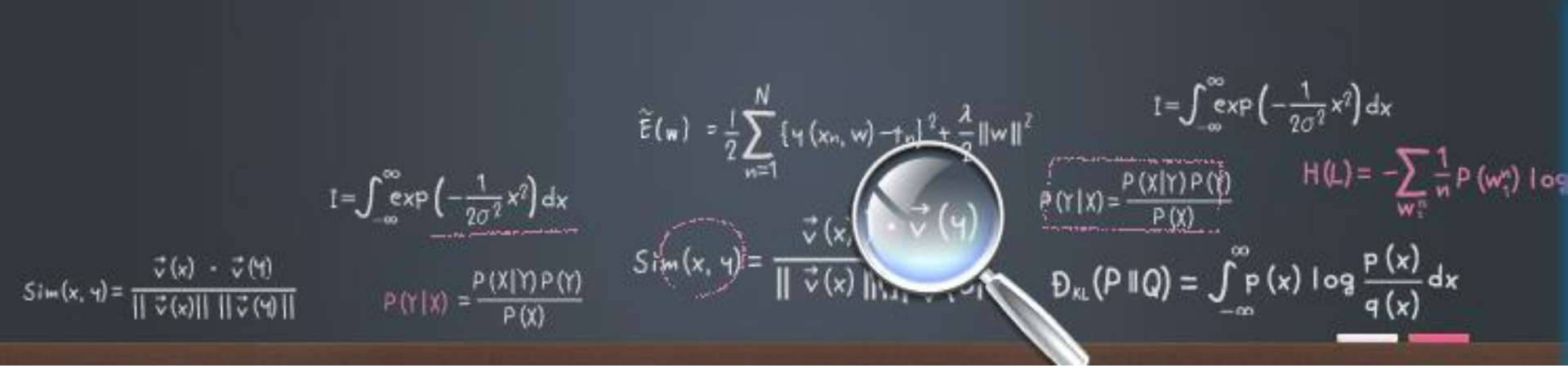

Which One Is Better: Presentation-Based or Content-Based Math Search?

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Outline

- Introduction
- Math Search Systems
- Method
- Evaluation
- Conclusion

Introduction

- Math Search
  - Presentation-based
    - LaTeX
    - Presentation MathML
  - Content-based
    - Content MathML
    - OpenMath
- NTCIR Math Track
  - http://ntcir-math.nii.ac.jp/

Introduction

- Content-based systems use SnuggleTeX or LaTeXML for semantic enrichment
- No evaluation of how semantic enrichment module contribute to search system
- Which one is better: content-based search or presentation-based search

Mathematical Search Systems

- Presentation-based systems
  - Springer LaTeX Search
  - MathFind
  - The Digital Library of Mathematical Functions
  - EgoMath
  - Math Indexer and Searcher
  - ActiveMath
  - …

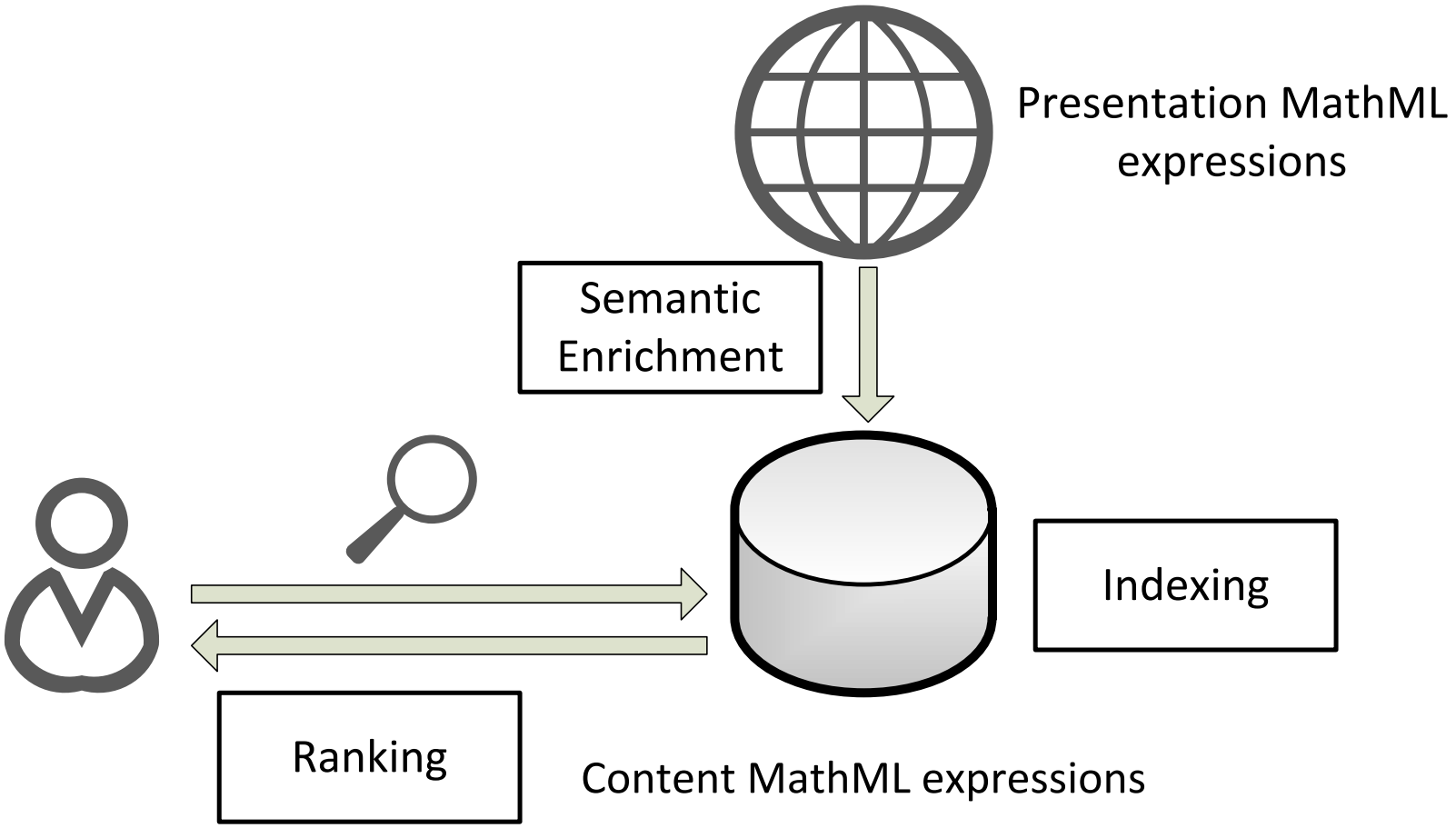
Mathematical Search Systems

- Content-based systems
  - Wolfram Function
  - MathWebSearch
  - MathGO!
  - MathDA
  - The system of Nguyen et. al
  - …

Method

- Use Semantic Enrichment module to convert Presentation to Content MathML
- Use Content MathML for Indexing
- Allow user to input query in Presentation MathML

System framework



Semantic Enrichment

- Semantic Enrichment method of Nghiem et. al (CICM 2013)
  - Segmentation rules: segment Presentation MathML trees into smaller trees
  - Translation rules: translate Presentation MathML trees to Content MathML trees
  - Each rule is associated with a probability

Indexing

- Indexing method of Topic et. al (NTCIR 2013)
  - Opaths: path in XML tree with order
  - Upaths: no order
  - Sisters: sister nodes in subtree

Evaluation

- Data
  - 20k Math expressions in WFS
  - 15 queries (modified from NTCIR)
- Systems
  - Presentation MathML (PMathML)
  - Content MathML (CMathML)
  - Semantic Enrichment (SE)

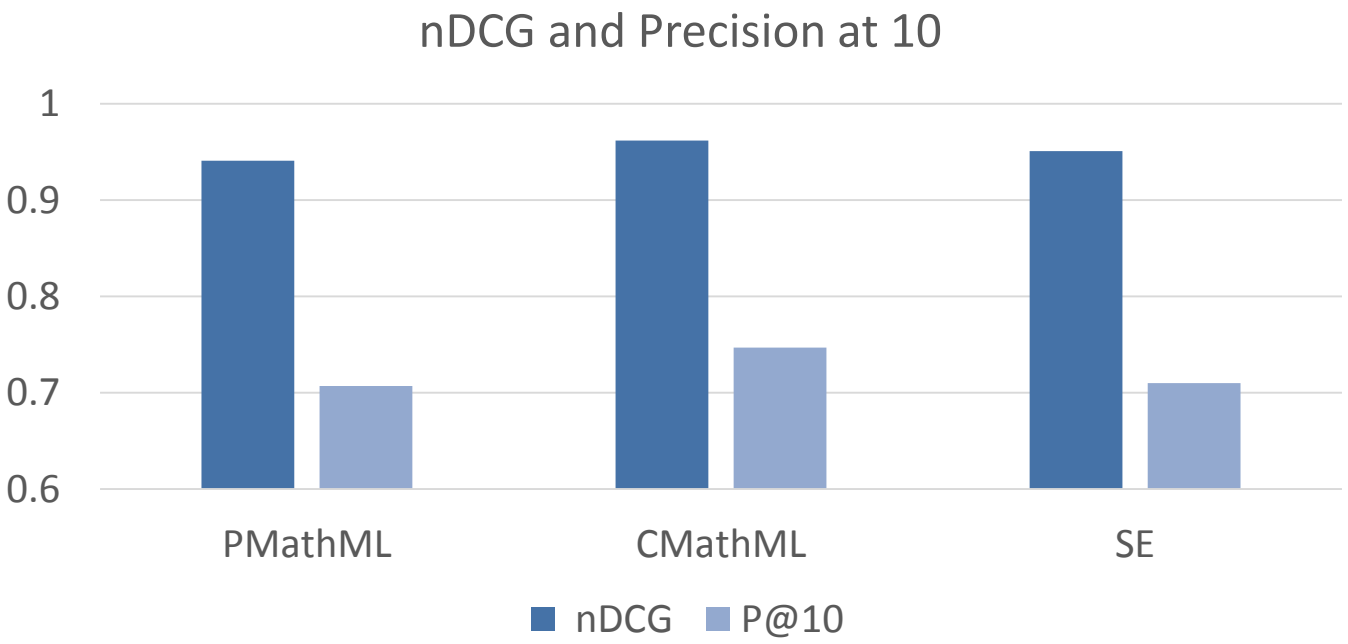
Evaluation

- Metrics
  - Precision at 10 (P@10)
    - Precision in top k results
  - Normalize Discounted Cumulative Gain (nDCG)
    - Ranking quality

Queries

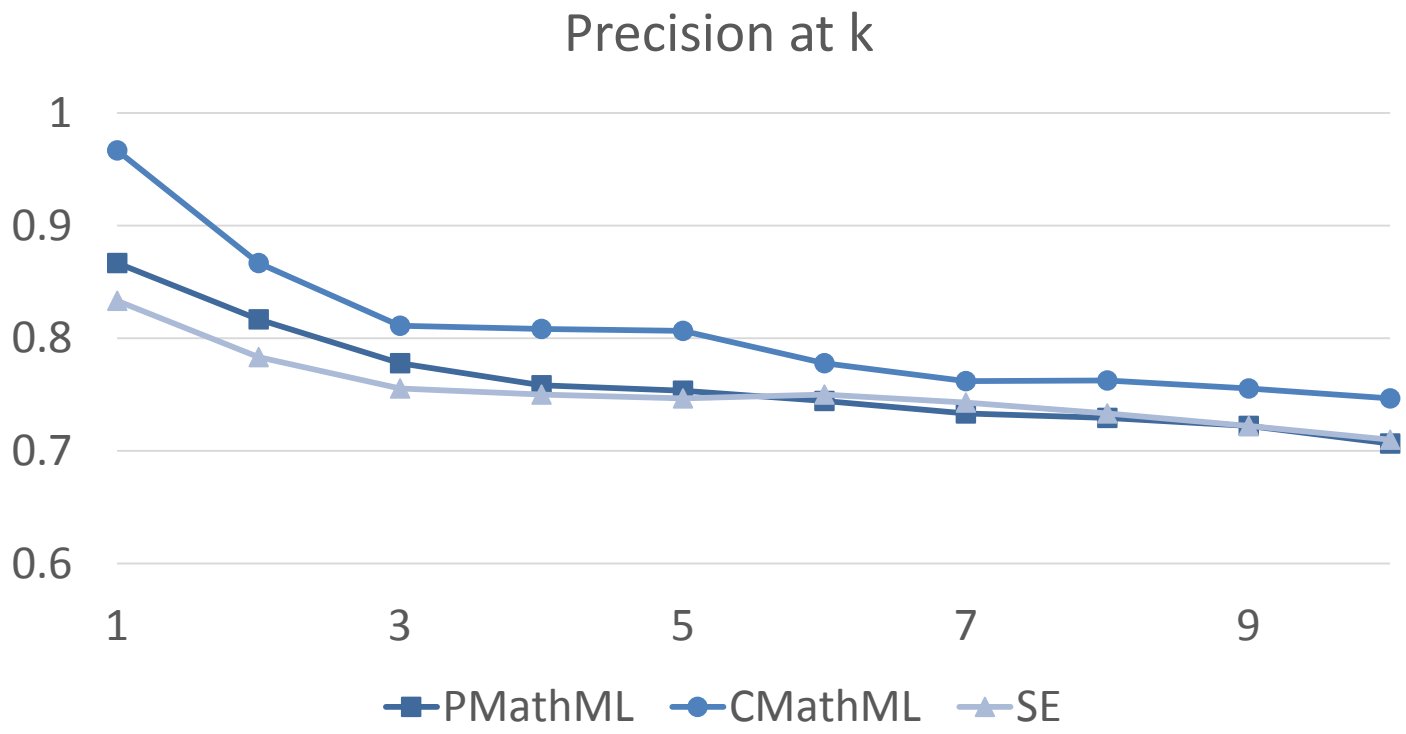
$\int_0^\infty x dx$	$x^2 + y^2$	$\int_0^\infty e^{-x^2}\, dx$
$arcsin(x)$	k^2	$\frac{\cosh ez + \sinh ez}{e}$
$\mathcal{R}_z \psi^\nu(z), \widetilde{\infty}$	$\int \frac{a^{d+bz}}{z} dz$	$\lim_{\nu \to \infty} \frac{L_{\alpha+\nu}}{L_\nu}$
$\mathcal{BP}_z \mathfrak{P}_\nu^\mu(z)$	$\nu \in \mathbb{N}$	$\psi^\nu(z)$
$\log(z+1)$	$H_n(z)$	$\frac{1}{\pi}\int_0^\pi \cos tn - z\sin t$

Evaluation: search performance



Using content markup improve search performance

Evaluation: search performance



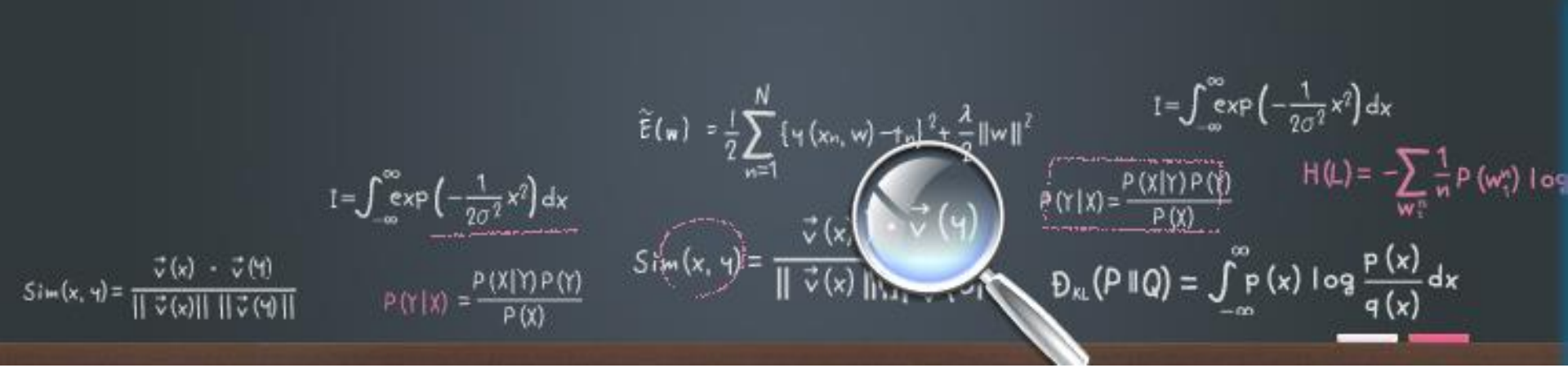
Using content markup improve search performance
Relevant results are ranked higher

PMathML and SE systems

- SE system is better
  - Functions have specific meanings
    - Poly-Gamma, Hermite-H
  - More than one way to represent math expression
    - Sin^{-1} and Arcsin
- PMathML system is better
  - Elementary functions
    - Power, Logarithm, Trigonometric functions

Summary

- Content-based math search is better than presentation-based math search
- Performance of semantic enrichment module affect the math search performance
- Both presentation-based and content-based systems have their strong points



ThΔnk you

∫or your Δtteηtioη!