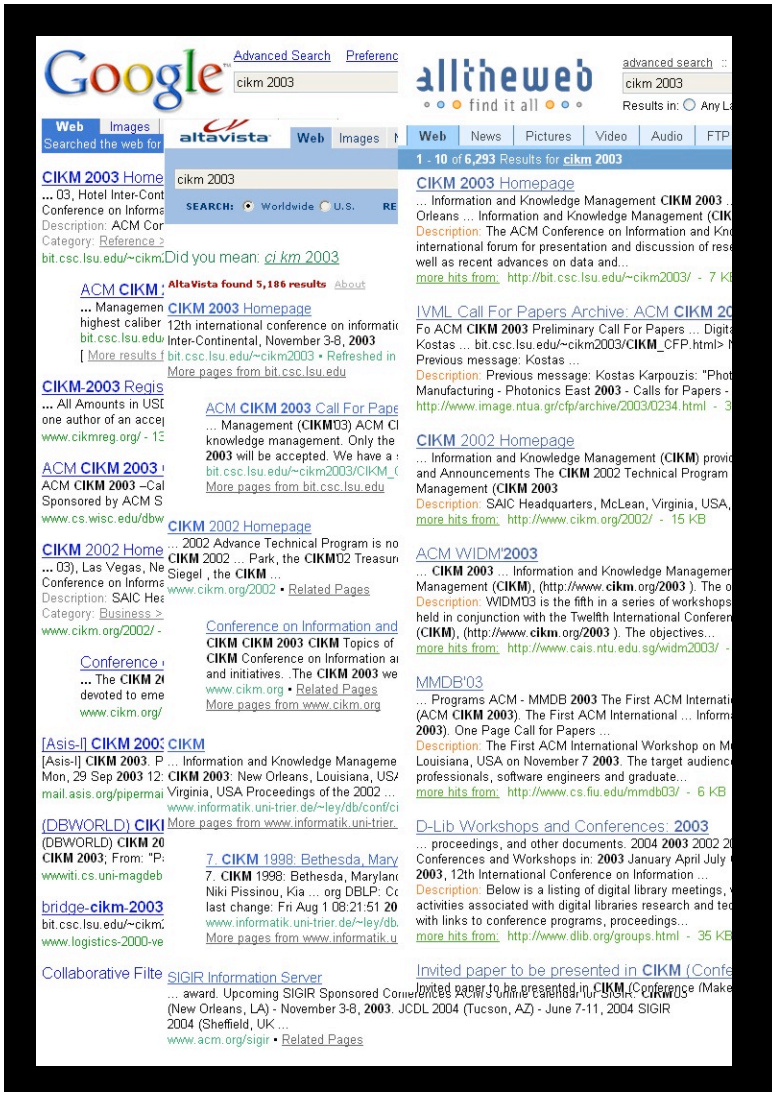
unified model for metasearch, pooling and system evaluation

Javed Aslam
Virgil Pavlu
Robert Savell

motivation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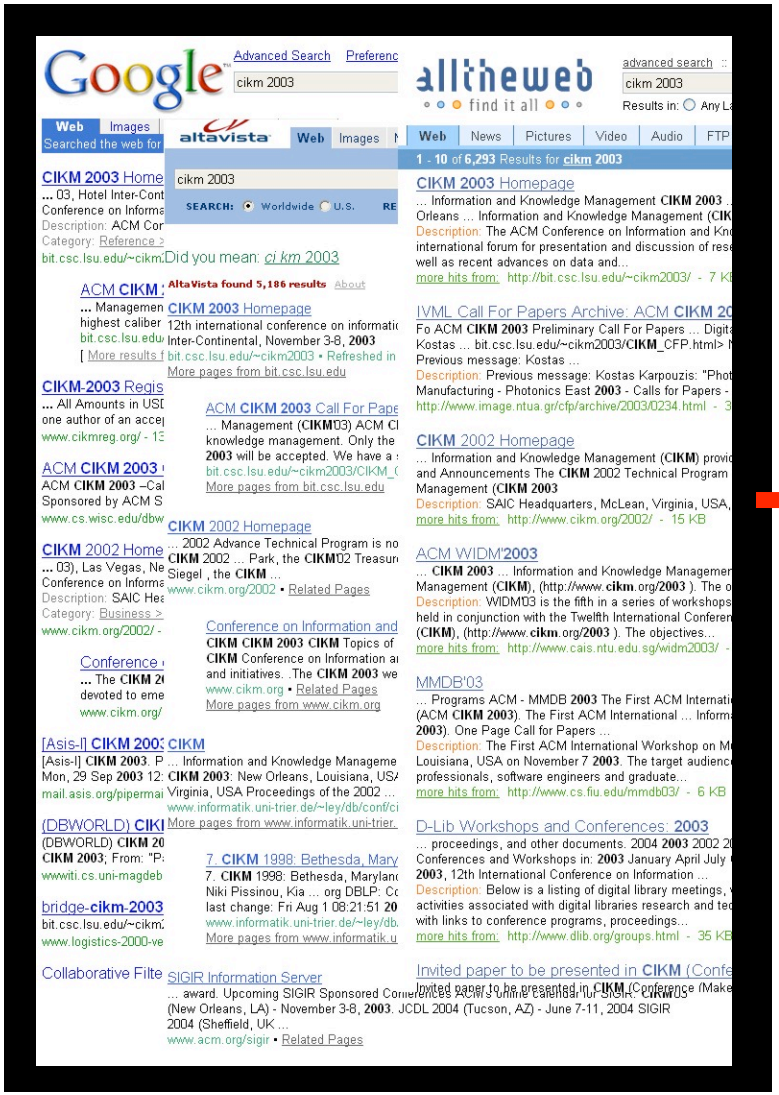

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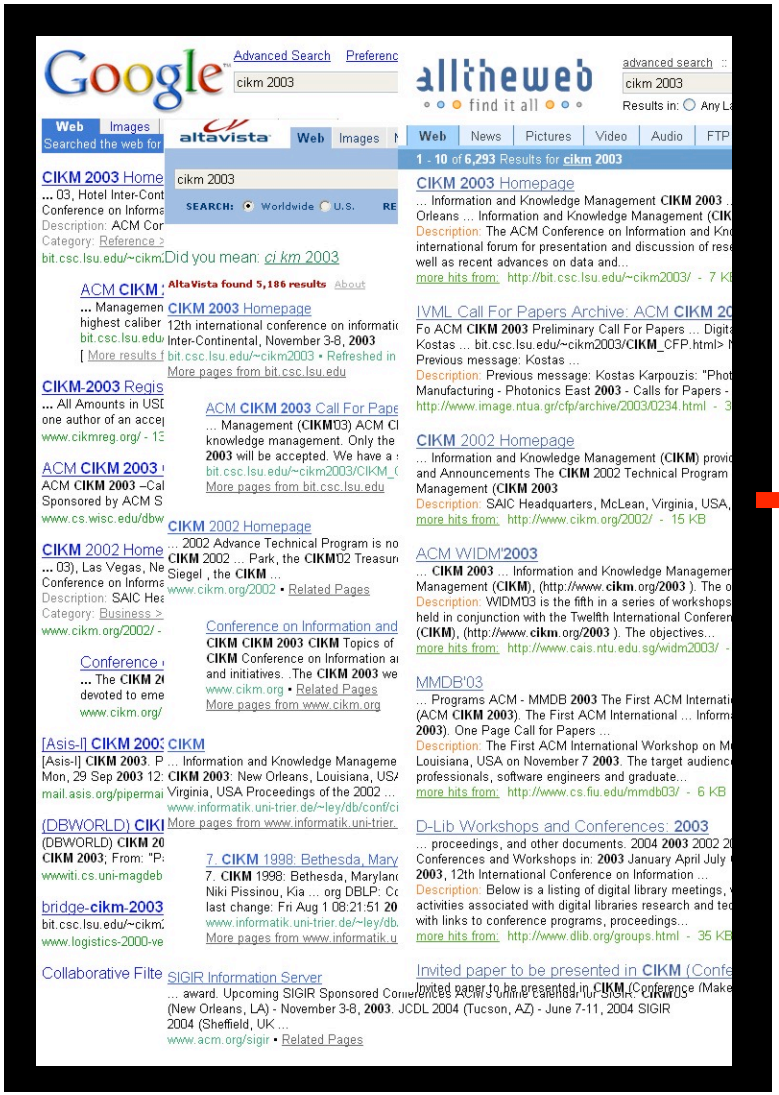

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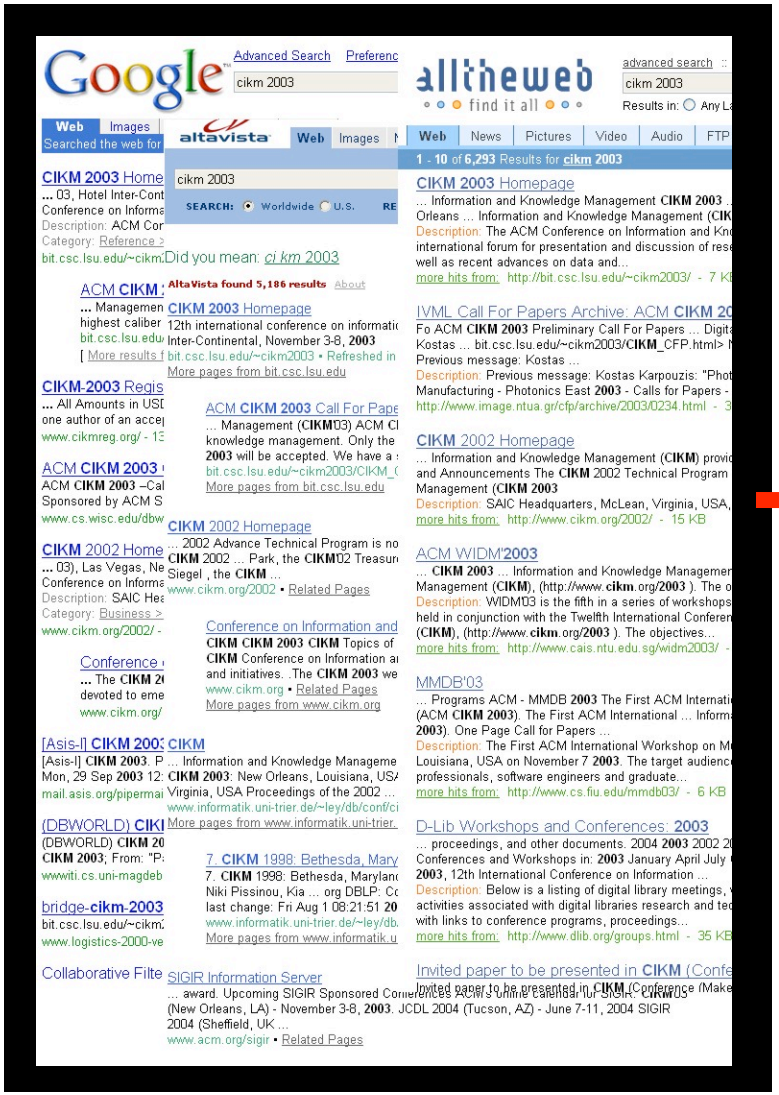

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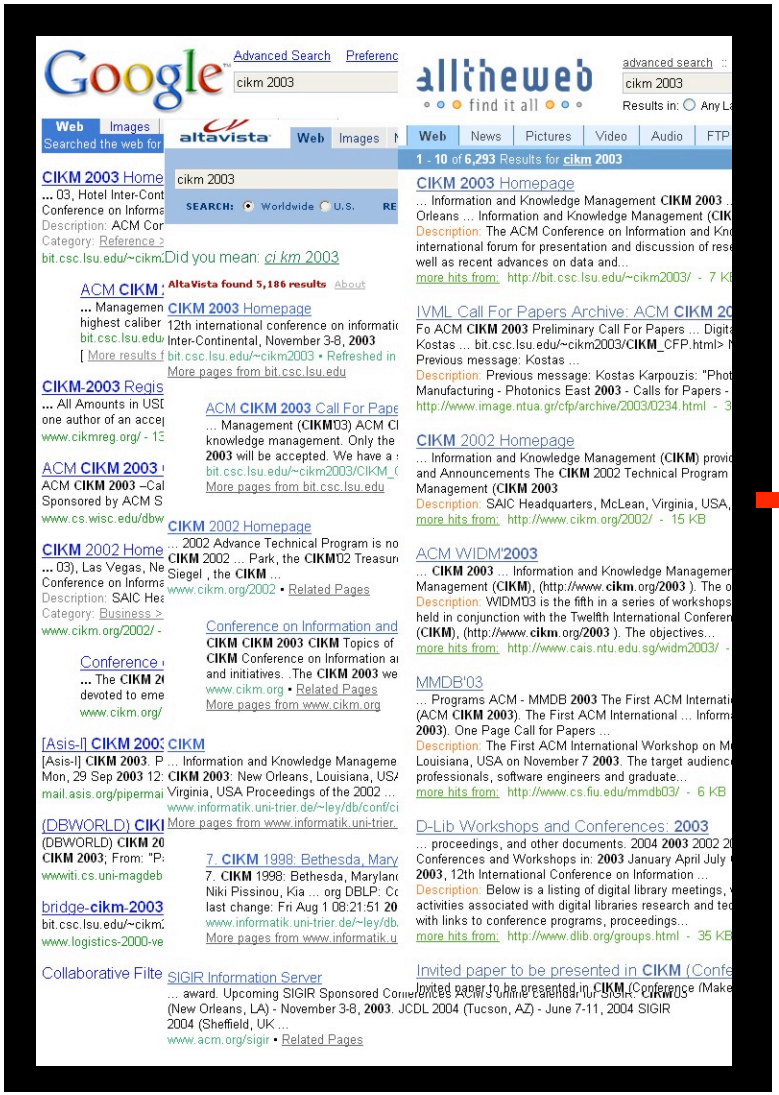

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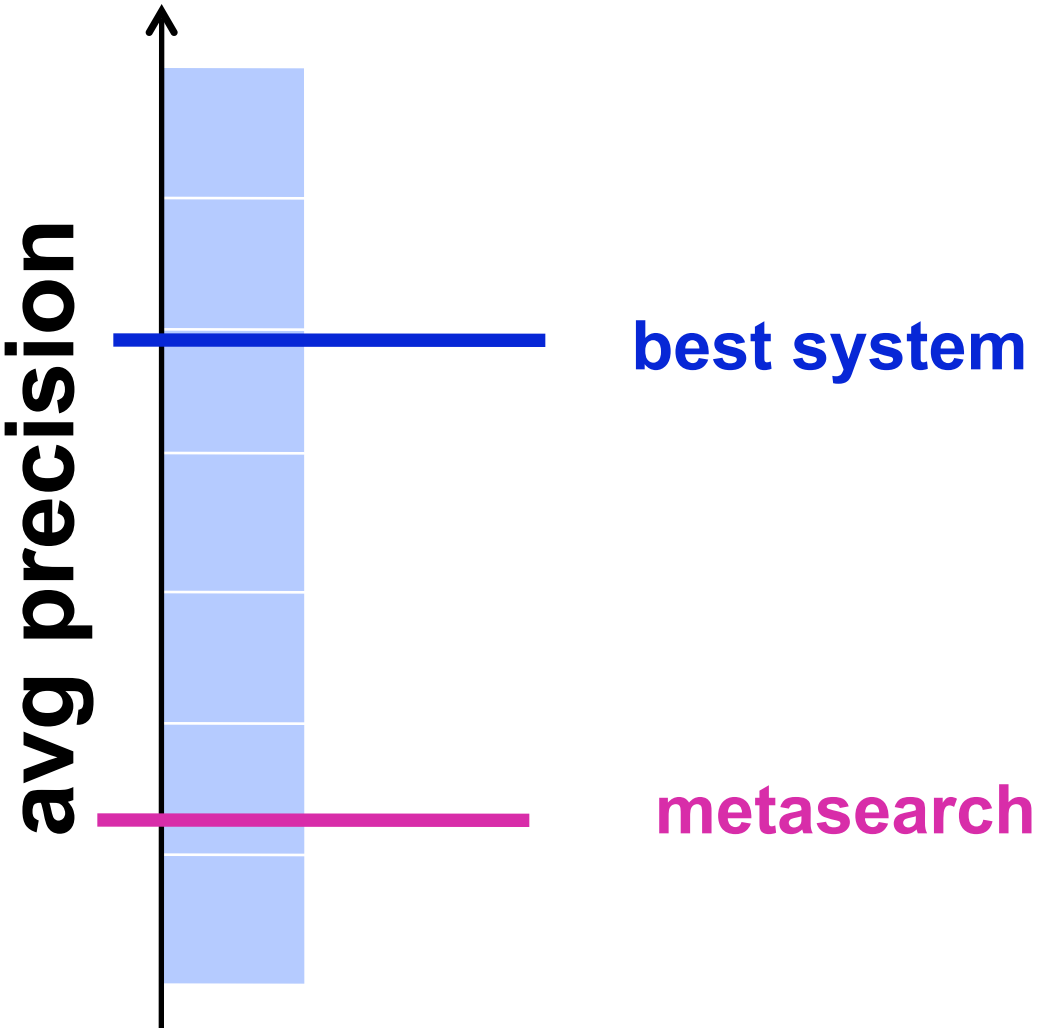

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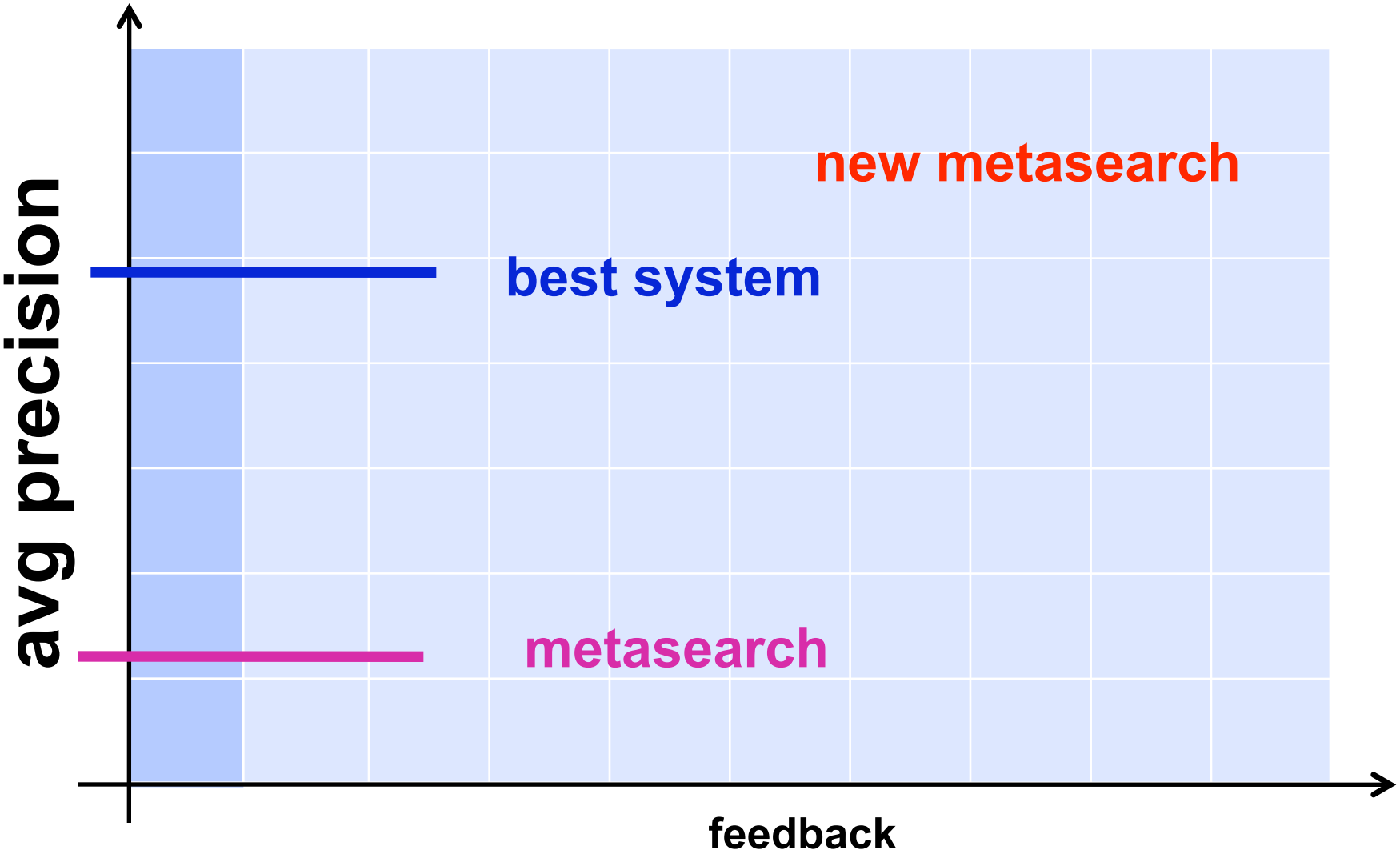
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new metasearch
best system
metasearch
feedback

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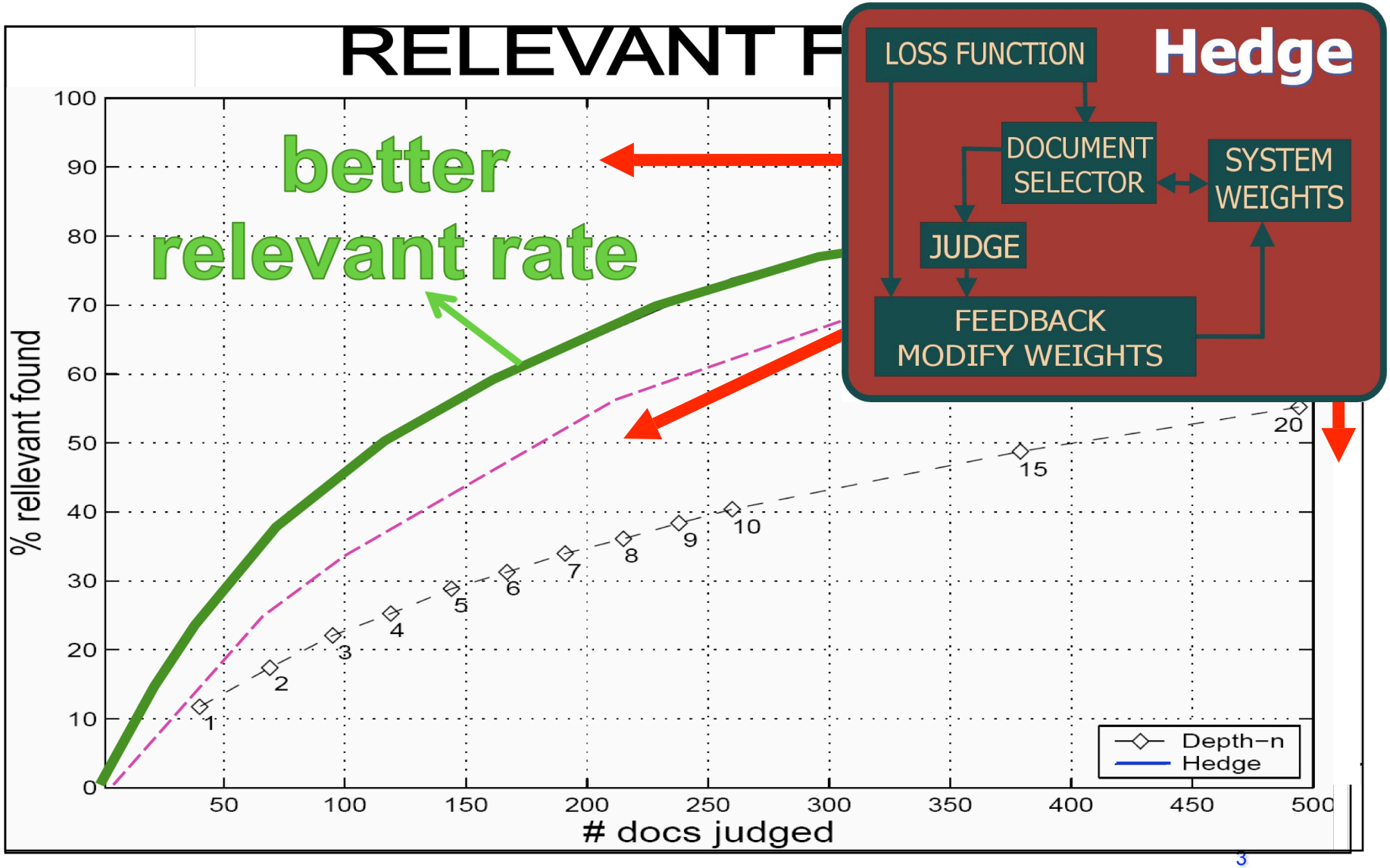
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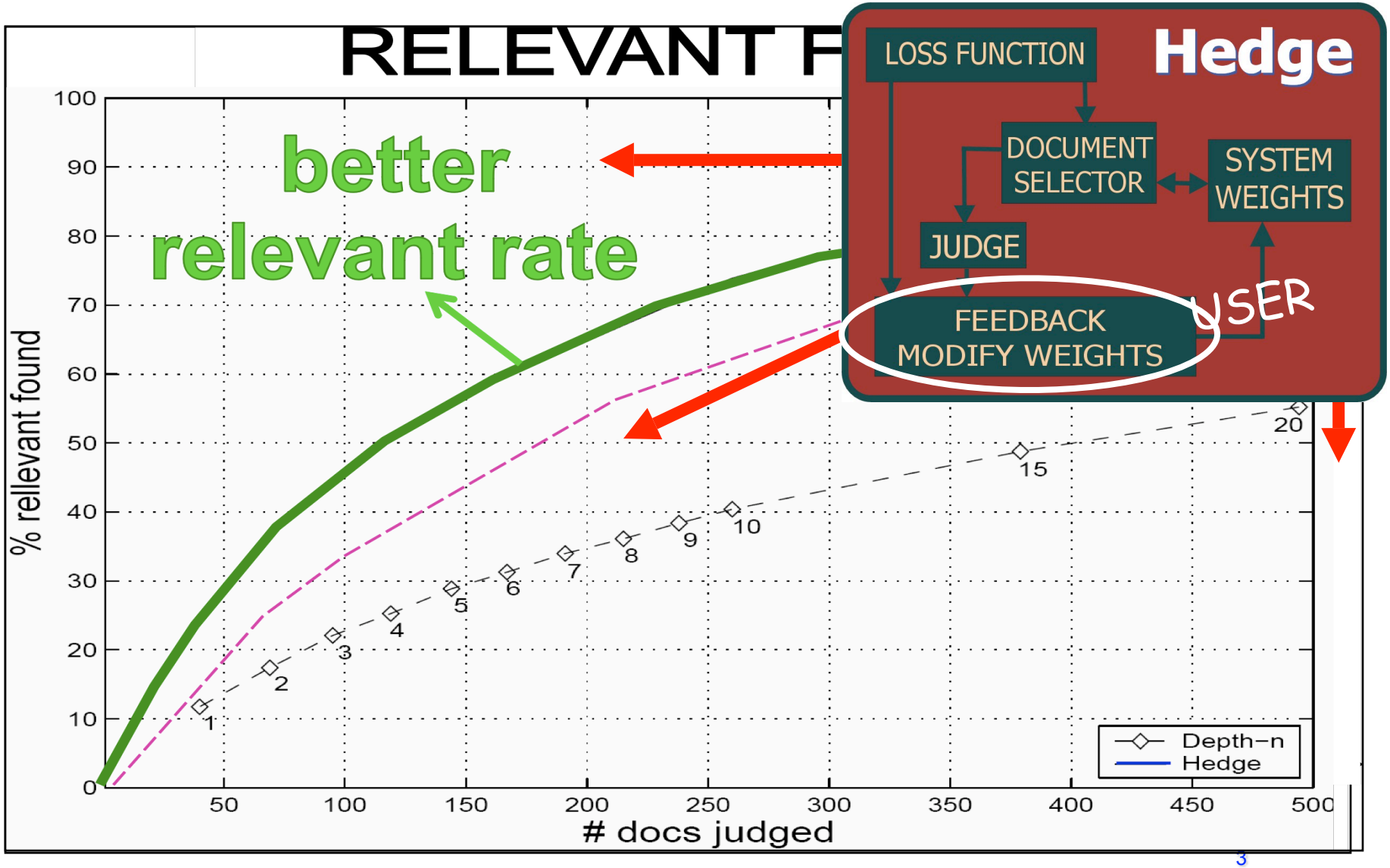
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# docs judged
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Hedge

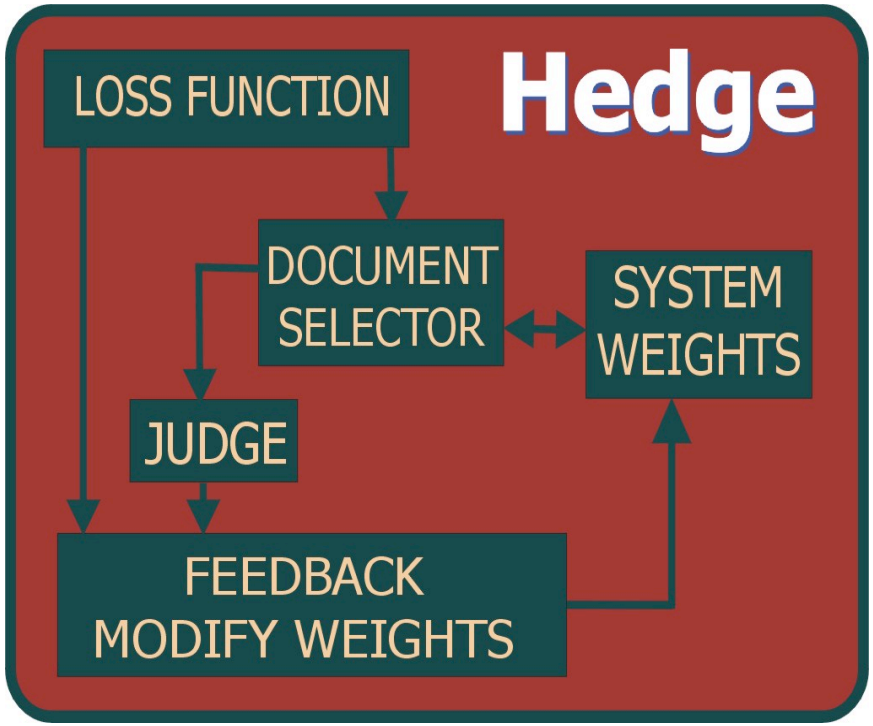
problem setup

- Set of underlying systems
  - On the same query
- User feedback
- Goal
  - Find relevant documents
  - Produce metasearch lists
  - Do partial system evaluation (distinction)
- We are looking for an adaptive approach

this talk

- Hedge algorithm
- The new model
- Loss function
- Pooling
- System evaluation
- Metasearch
- Experiments

online allocation - hedge algorithm



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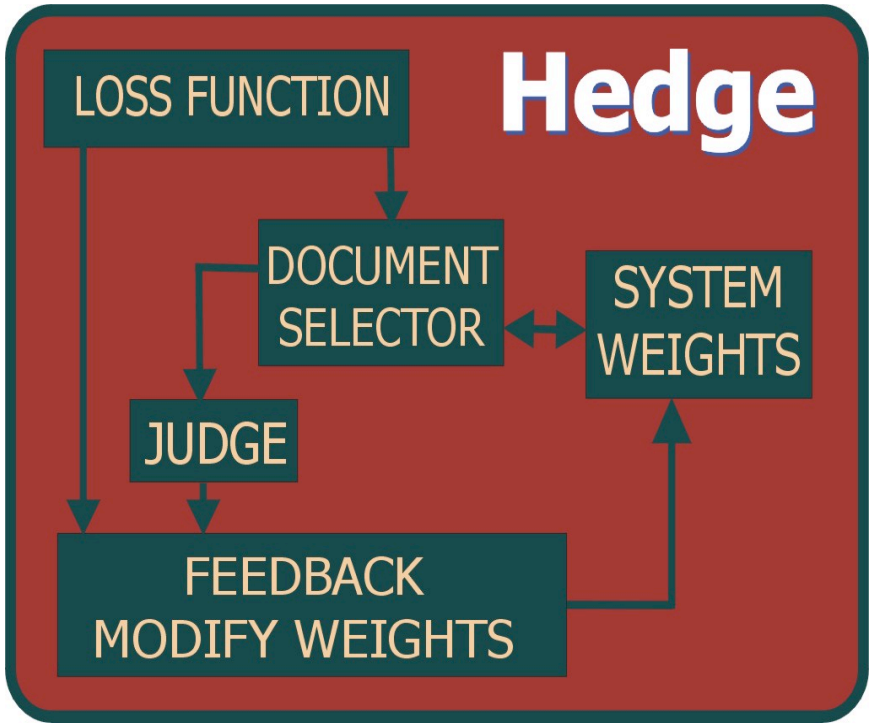
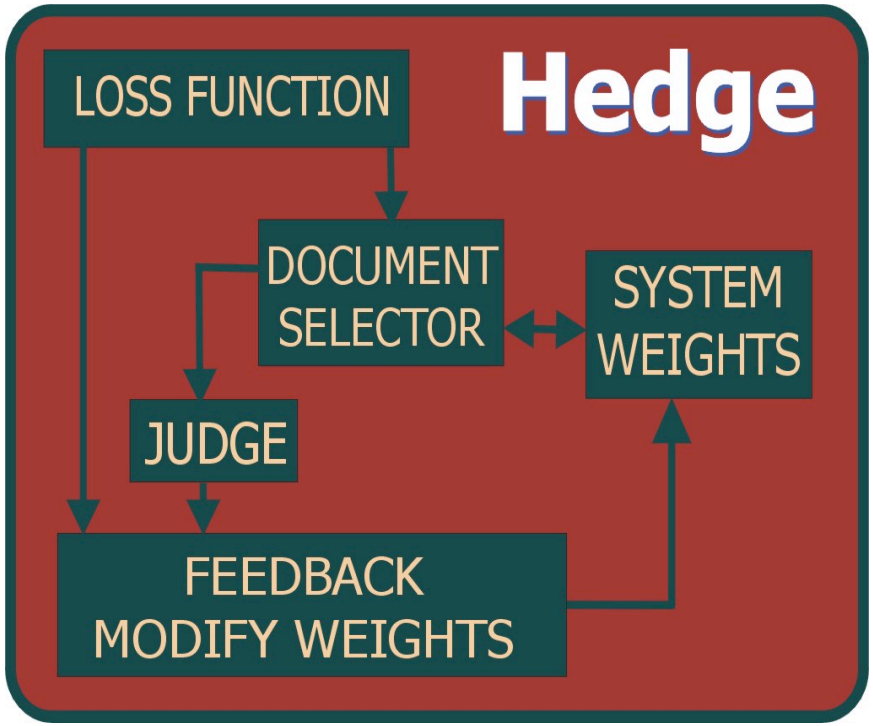


$\beta \in [0,1]$ N strategies (systems)

initial weights $\mathbf{w}^1 \in [0,1]^N$; $\sum_{i=1}^{N} w_i^1 = 1$

online allocation - hedge algorithm



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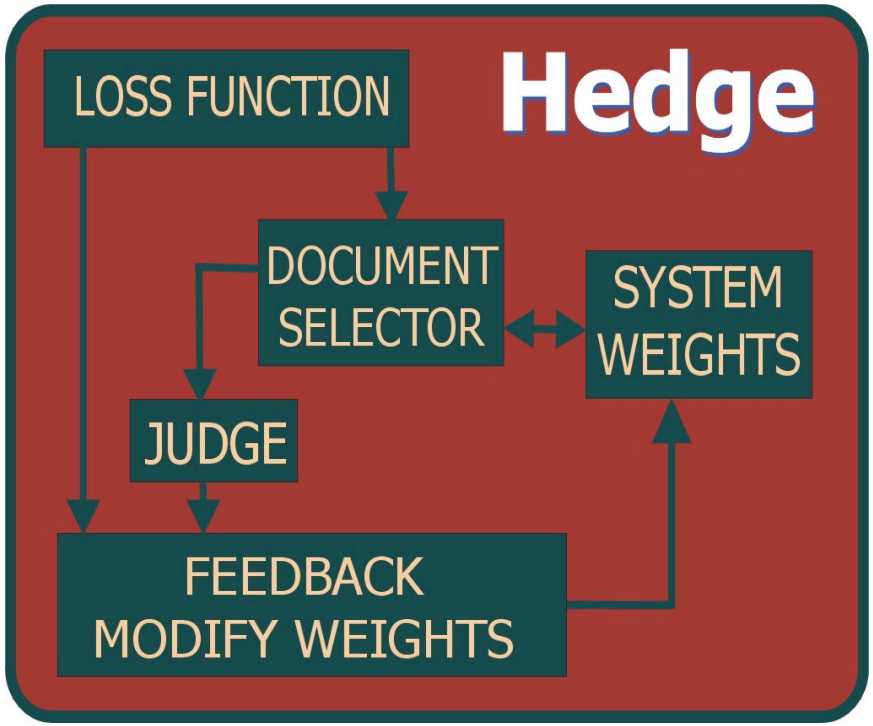
LOOP for episode t=1,2,…,T

online allocation - hedge algorithm



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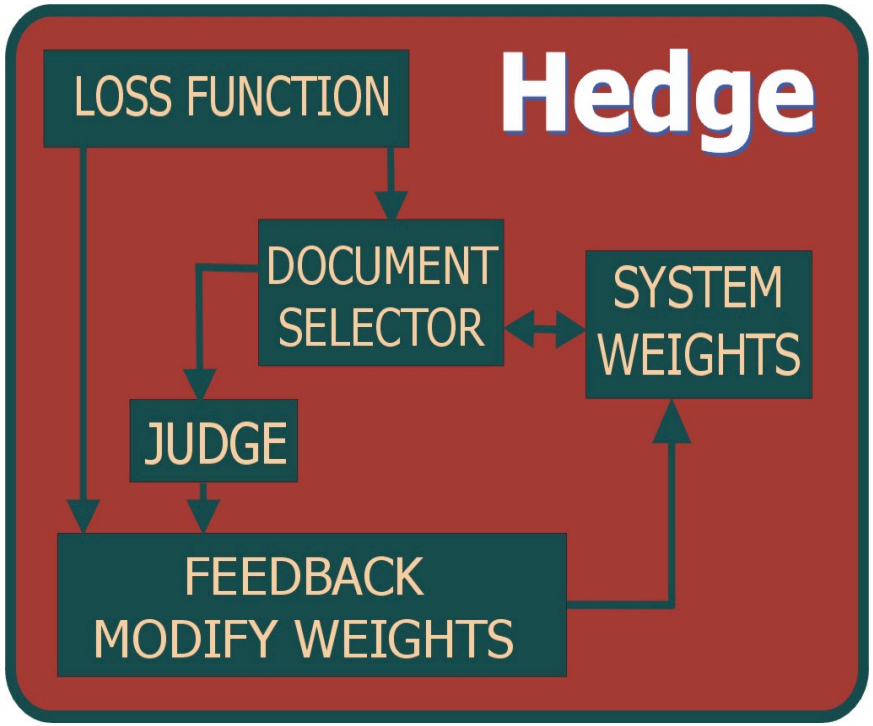
- Choose allocation

$$p_i^t = \frac{w_i^t}{\sum_{i=1}^{N} w_i^t}$$

online allocation - hedge algorithm



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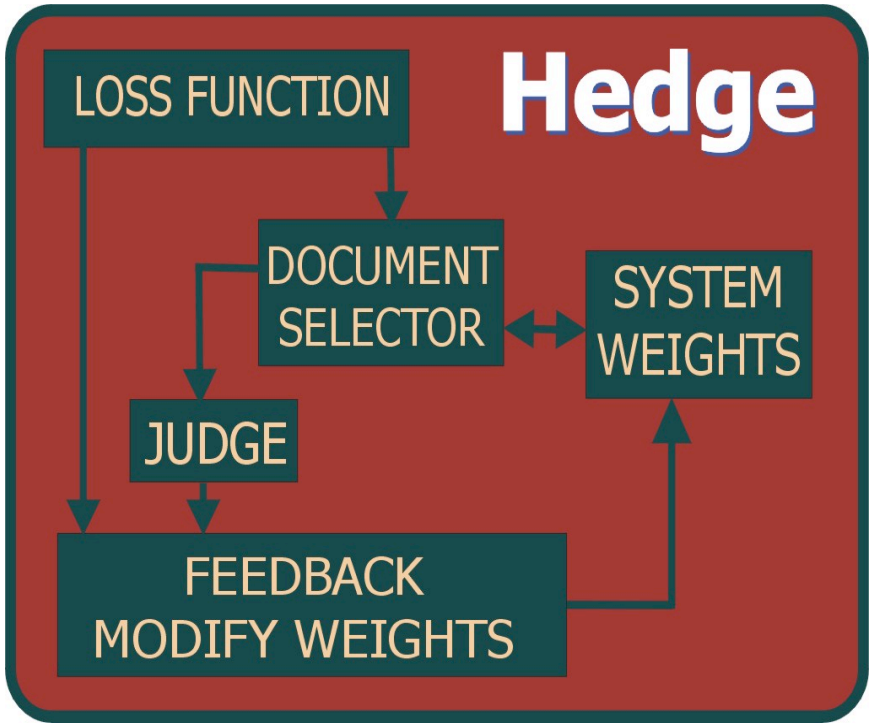
LOOP for episode t=1,2,....T

- Choose allocation $p_i^t = \frac{w_i^t}{\sum_{i=1}^{N} w_i^t}$
- Receive loss vector $l^t \in [0,1]^N$

online allocation - hedge algorithm



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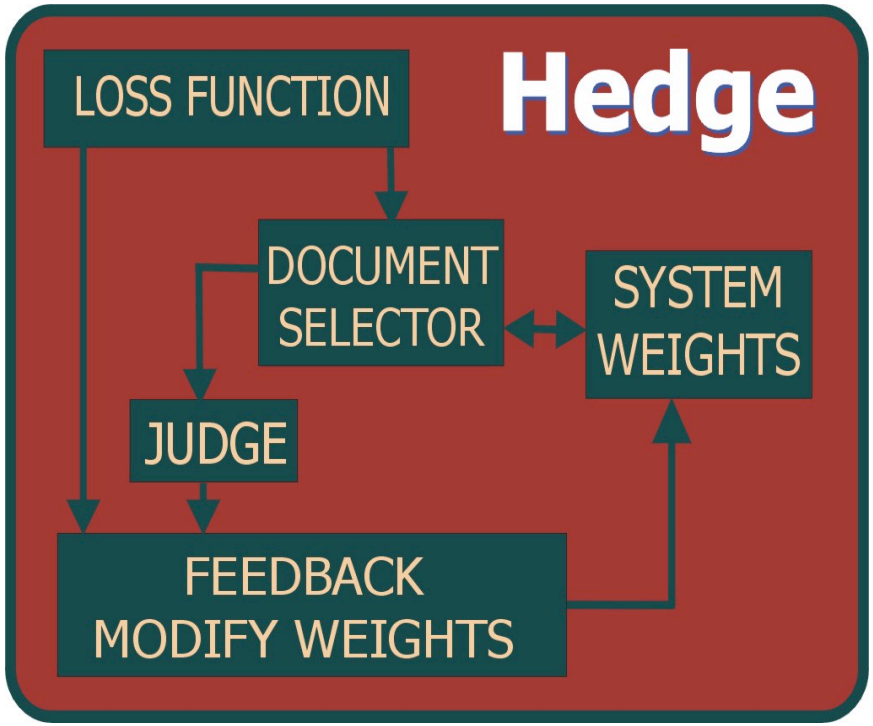

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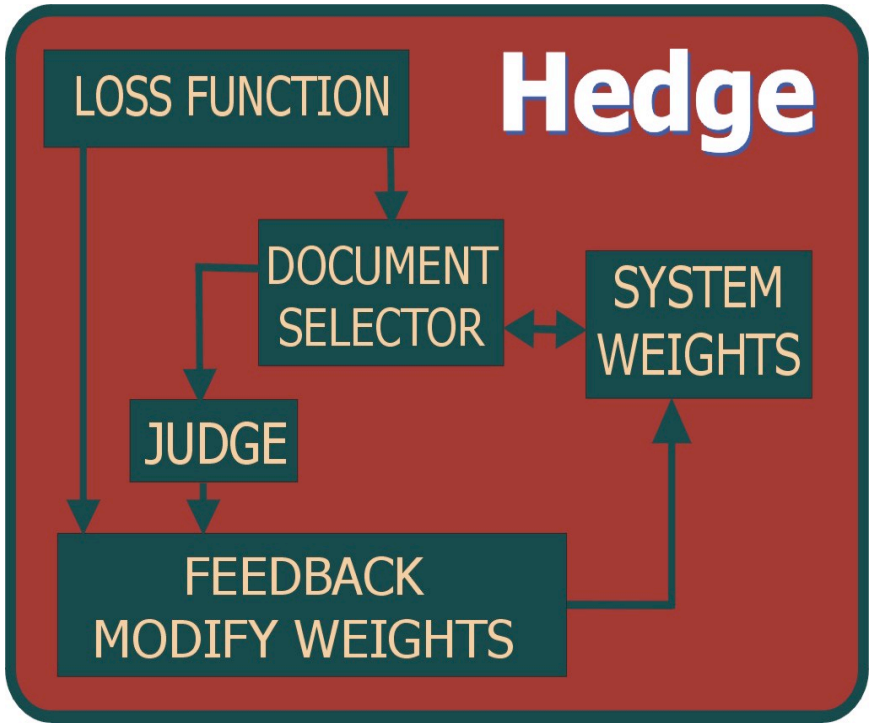
- Update weights $w_i^{t+1} = w_i^t \times \beta^{l_i^t}$

online allocation - hedge algorithm



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- Hedge loss

$$L_{HEDGE} = \sum_{t=1}^{T} p^t \cdot l^t$$

Why hedge [schapire, freund '96]

$$\sum_{i=1}^{N} w_i^{T+1} \leq \left(\sum_{i=1}^{N} w_i^{T} \right) \left(1 - (1-\beta)\mathrm{p}^{T} \cdot \ell^{T}\right) \leq \ldots.$$

Why hedge [schapire, freund '96]

$$\sum_{i=1}^{N} w_i^{T+1} \leq \left(\sum_{i=1}^{N} w_i^{T} \right) \left(1 - (1-\beta)\mathrm{p}^{T} \times l^{T}\right) \leq \ldots.$$

hedge loss at episode T $= p^{T} \times l^{T}$

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hedge loss at episode T $= p^T \ell^T$

cummulat loss L_{HEDGE}

$$L_{HEDGE} \le \frac{\ln\left(\frac{1}{\beta}\right) L_{SYSTEM} + \ln N}{1-\beta}$$

Our model

param $\beta \in [0,1]$; N systems; T trials

init $w_s^0 = \frac{1}{N} \quad \forall s \in \{1,2,...,N\}$;

FOR $t = 1,2,...,T$:

- select $d_t = \arg\max_{d \text{ not labeled}} \left[\sum_{s=1}^{N} w_s^{t-1} * LOSS(d, s \mid d = NR) \right]$
- judge d_t : find out $label(d_t)$
- apply feedback $w_s^t = w_s^{t-1} * \beta^{LOSS(d,s)}$

FACT : if we label all docs : $w_s^{final} = \beta^{C*(Z-2*TP(s))}$

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FACT : if we label all docs : $w_s^{final} = \beta^{C*(Z-2*TP(s))}$

pooling - howto

- select $d_t = \arg\max_{d \text{ not labeled}} \left[\sum_{s=1}^{N} w_s^{t-1} * LOSS(d, s \mid d = NR) \right]$

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- Naturally “want” top ranks
- If NON RELEVANT, then a NR in top ranks of the system lists
- If RELEVANT, bingo.

Loss function

$$LOSS(d,s) = label(d) * \left(\frac{1}{r} + \frac{1}{r+1} + \ldots + \frac{1}{Z} \right) \approx label(d) * \ln \frac{Z}{r}$$

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Z =# of documents returned by system s

$label(d) = -1$ if d is RELEVANT ; $+1$ if d is NONRELEVANT

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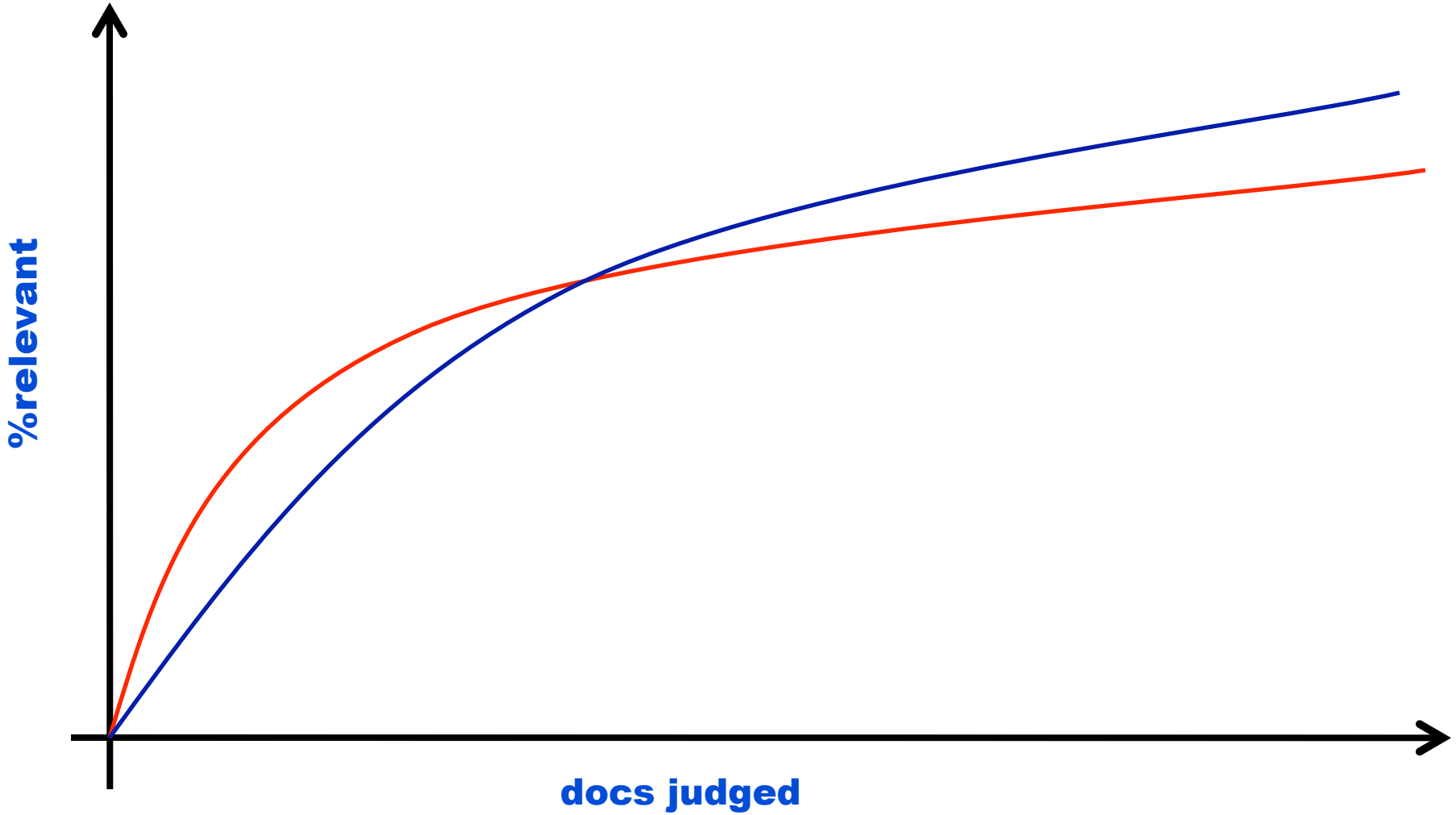
“total” precizion

- Average the precision at ALL ranks
  - Normalize so ideal system gets TP=1
- math is more simple
  - we still work on it though
- Bad with “long tails”

pooling - comparison with Cormack



[partial] system evaluation – howto

[partial] system evaluation – howto

- Before the next episode
  - Assume all docs not judged (so many ?) to be NR
  - Compute AvegPrecision for every system
- For comparison with depth-pooling we use average number of pools (over queries)
- Two situations
  - One (or few) very good systems – use small β
  - No singles

metasearch – howto

- Before the next episode
  - Compute “pooling value”

for each doc

$$\left[\sum_{s=1}^{N} w_s^{t-1} * LOSS(d, s \mid d = NR)\right]$$

  - Instead of “select the top doc” for pooling

do “select the top 1000 doc” for metasearch

- In fact almost 1000 – docs already pooled are automatically in top of metasearch list
  - Fair both ways

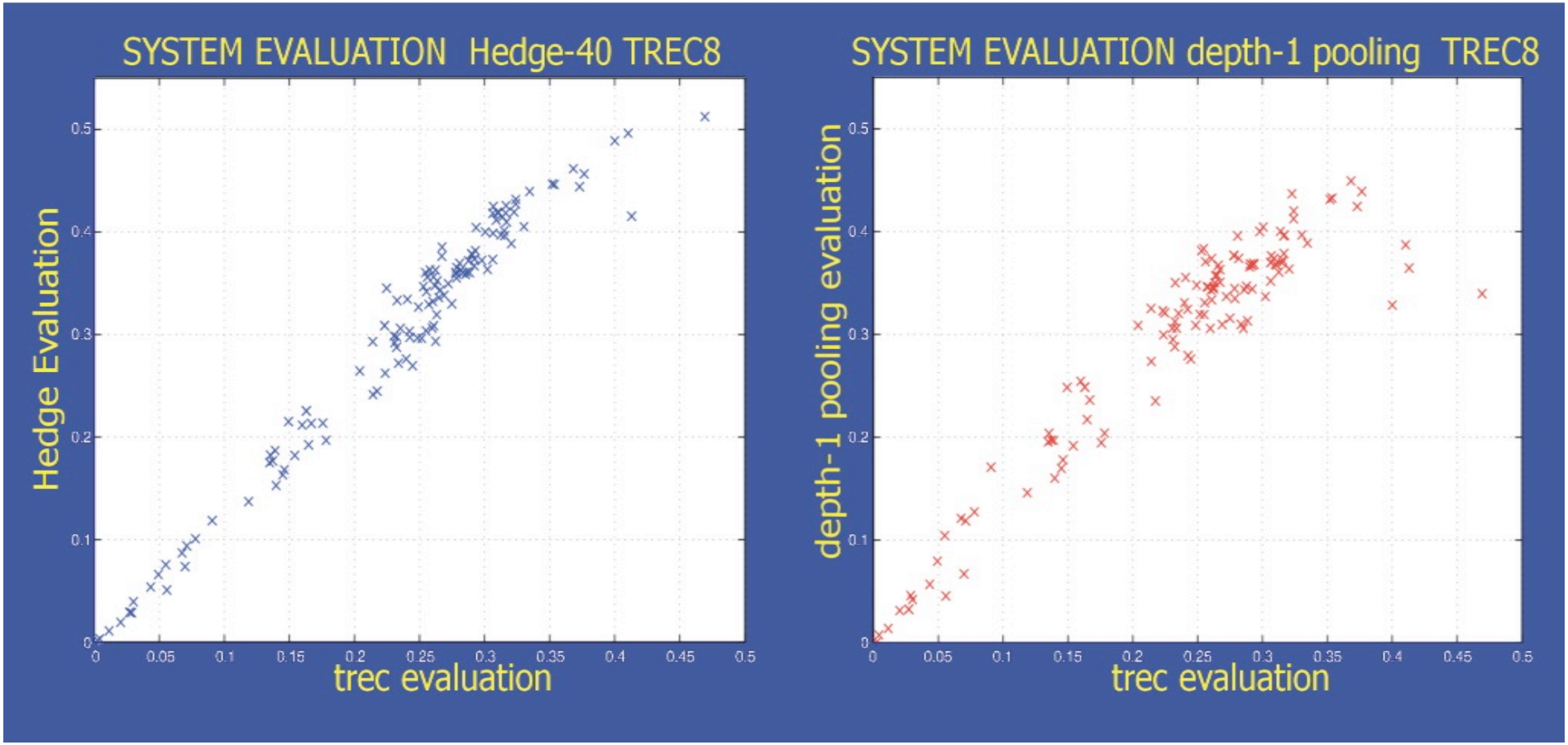
experiments

- TREC
  - ~100 systems
  - 50 queries each competition
- Use TREC qrels as user feedback
  - incomplete feedback

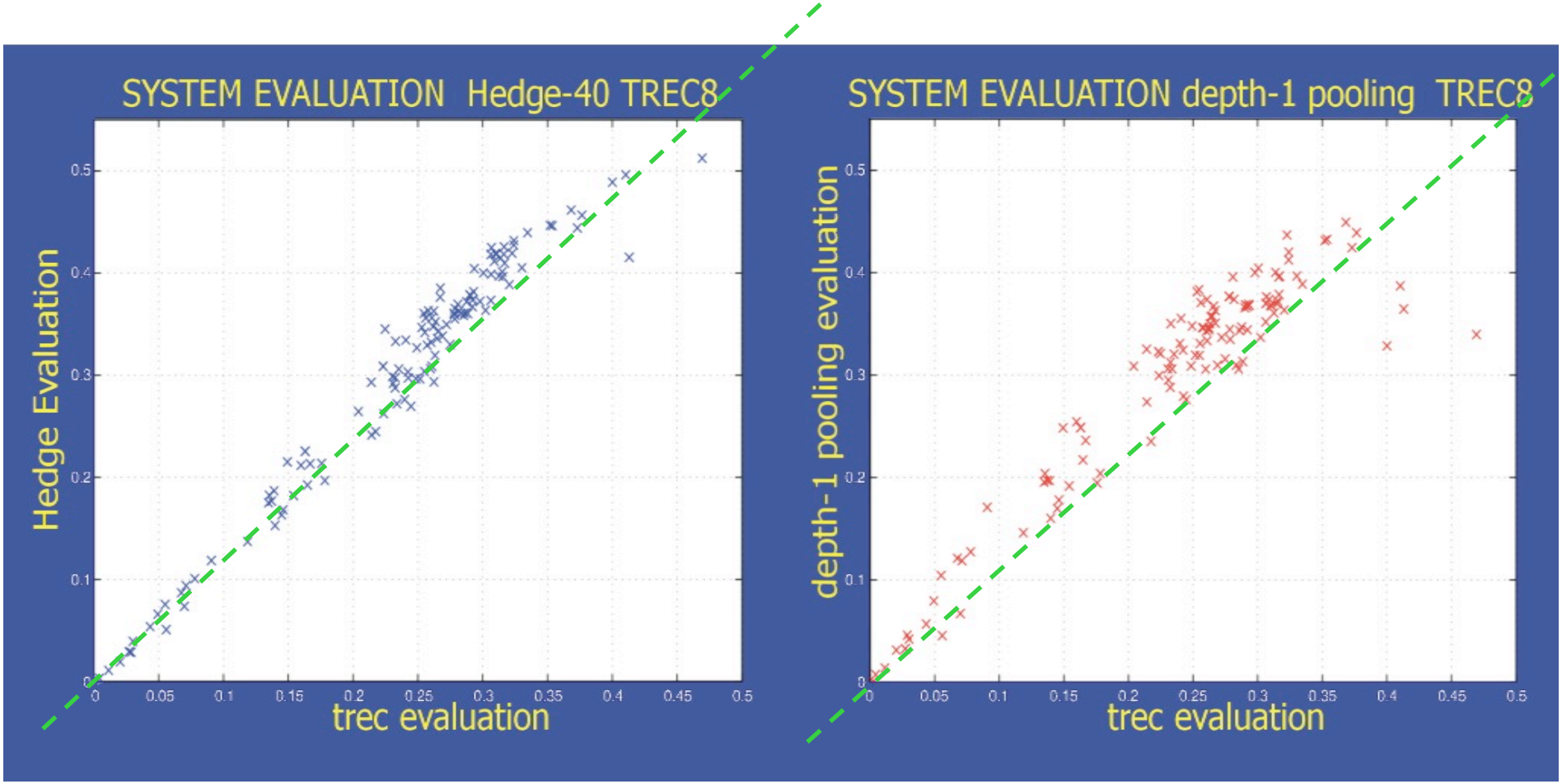
experiments

- TREC
  - ~100 systems
  - 50 queries each competition
- Use TREC qrels as user feedback
  - incomplete feedback
- Goal
  - Find relevant documents
  - Produce metasearch lists
  - Do partial system evaluation (distinction)

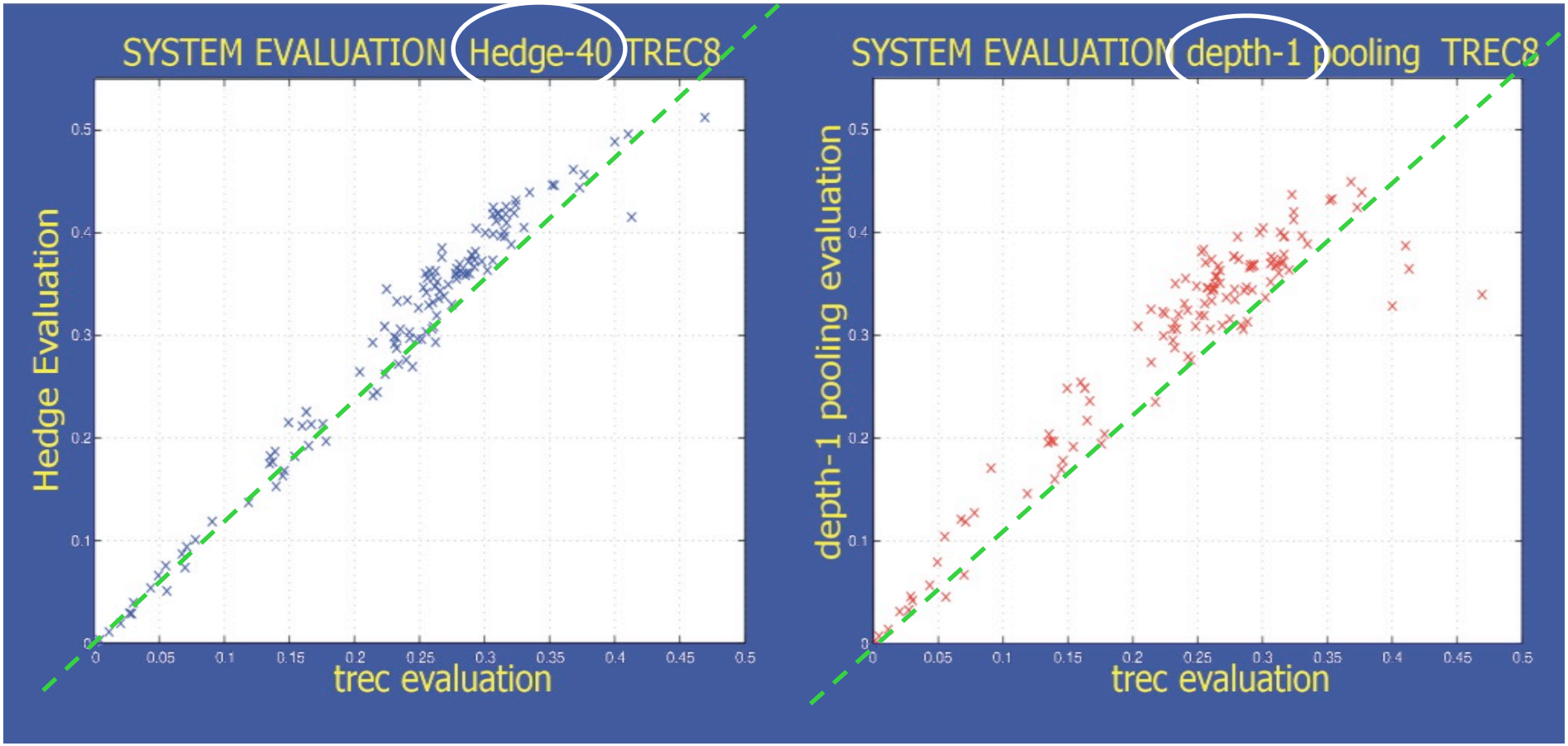
experiments - system evaluation



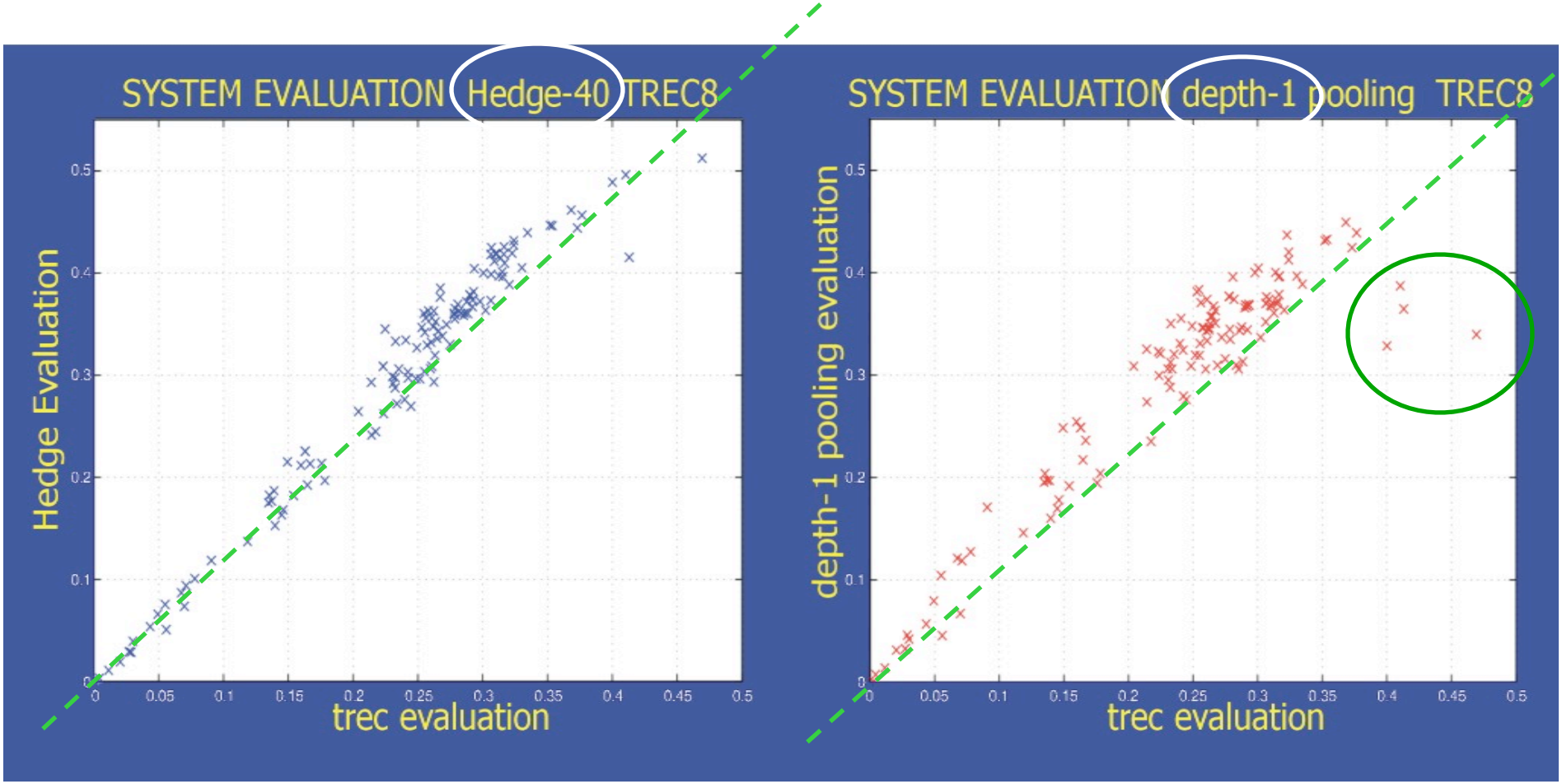
experiments - system evaluation



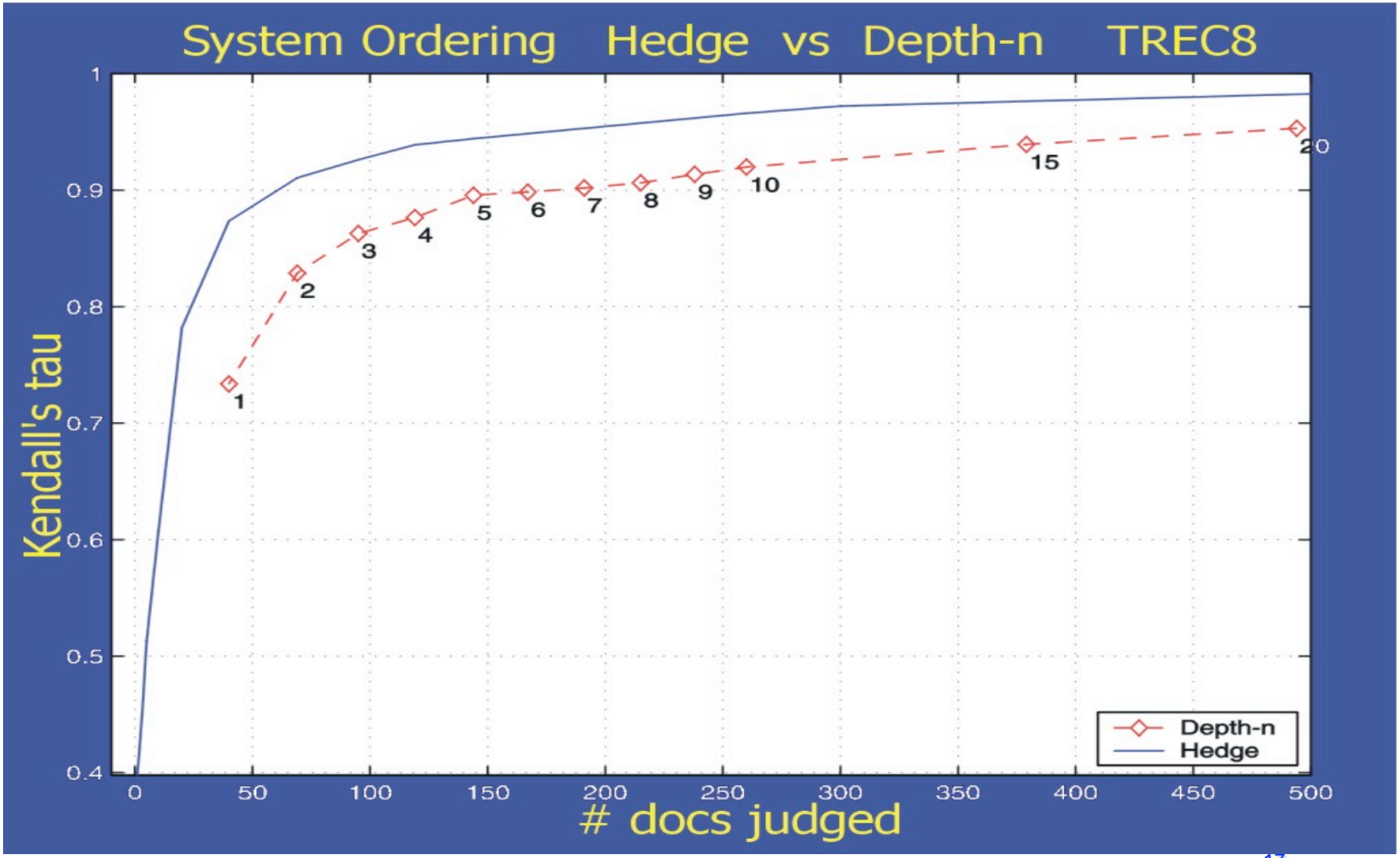
experiments - system evaluation



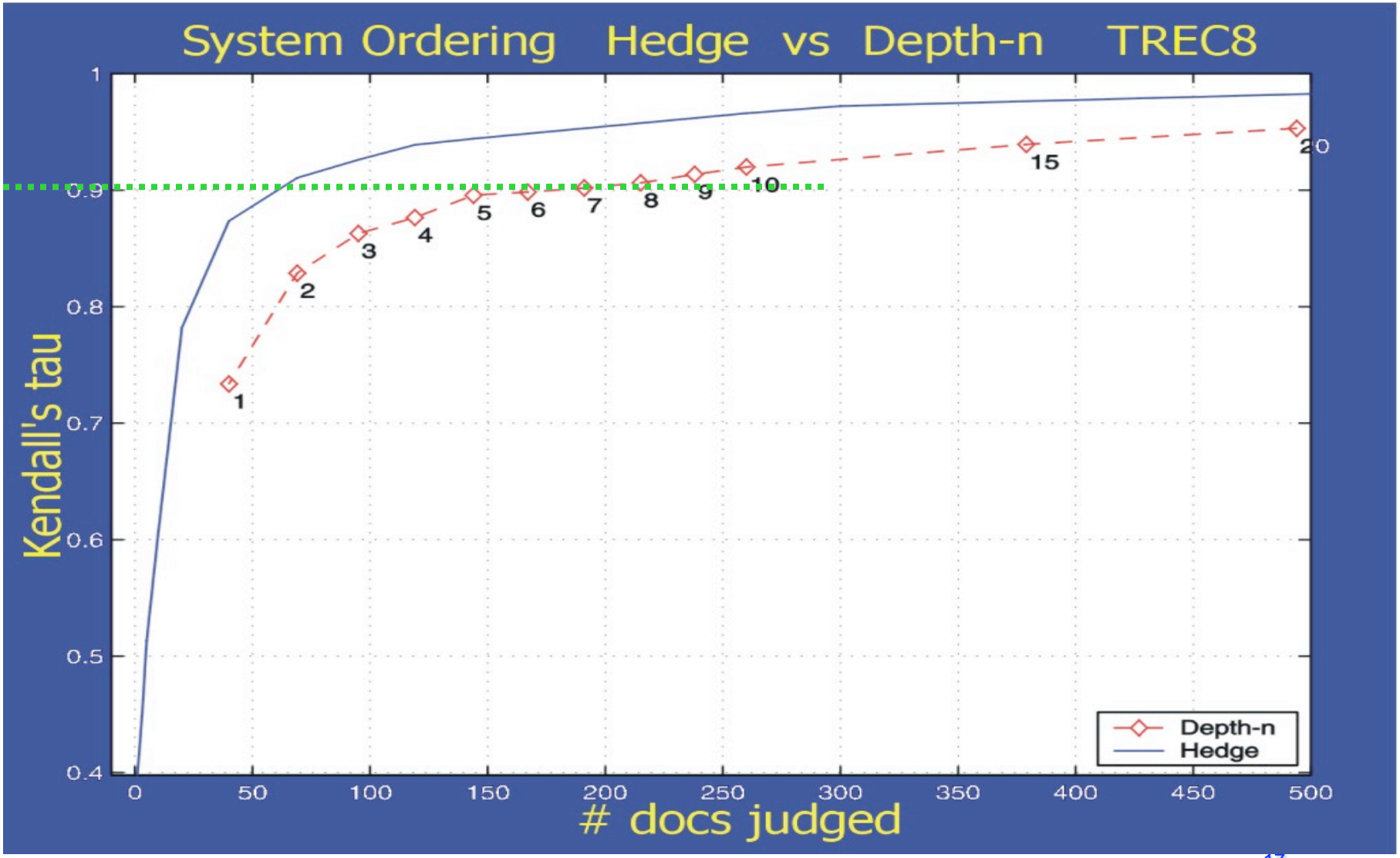
experiments - system evaluation



system evaluation – kendall's tau



system evaluation – kendall's tau



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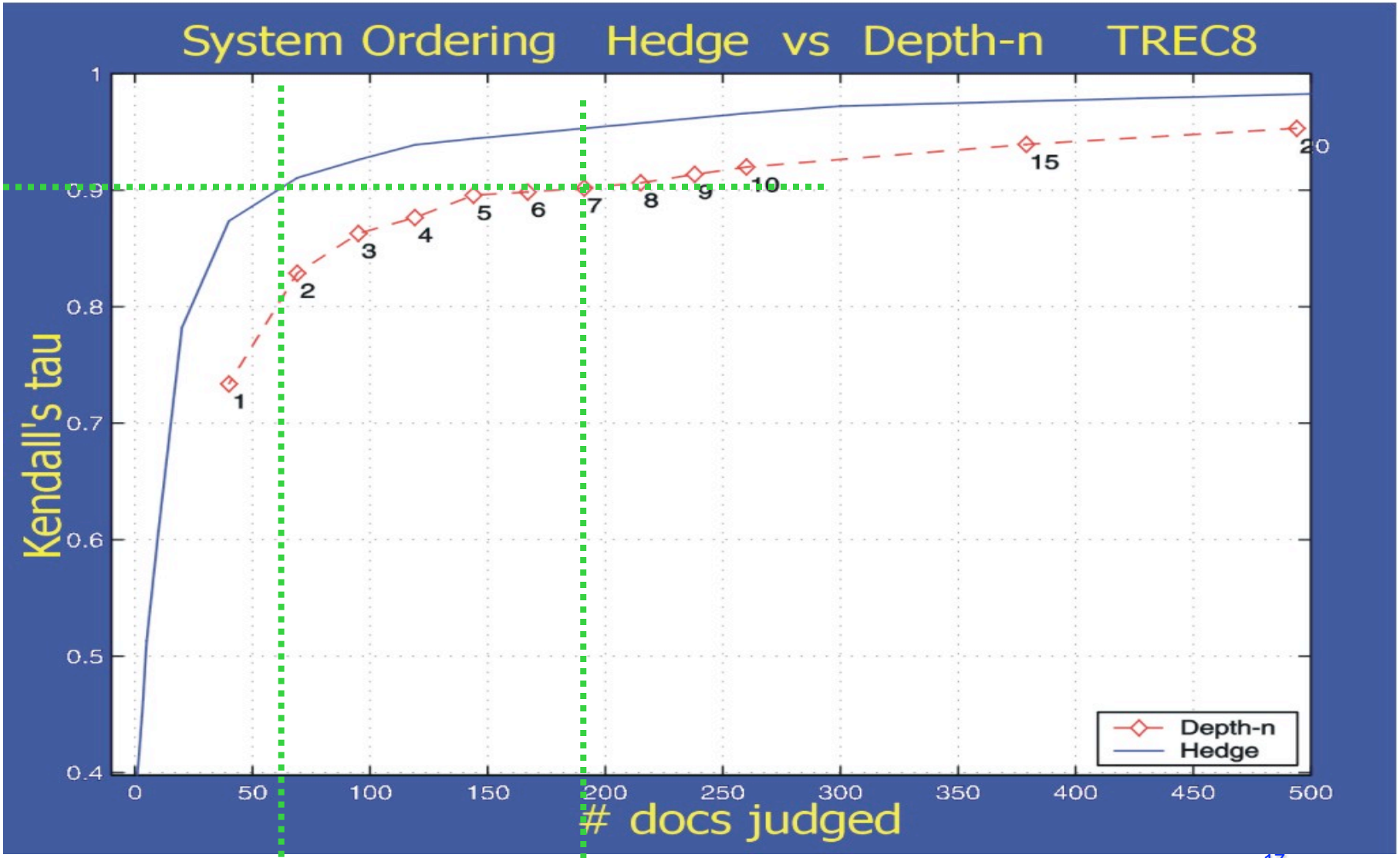
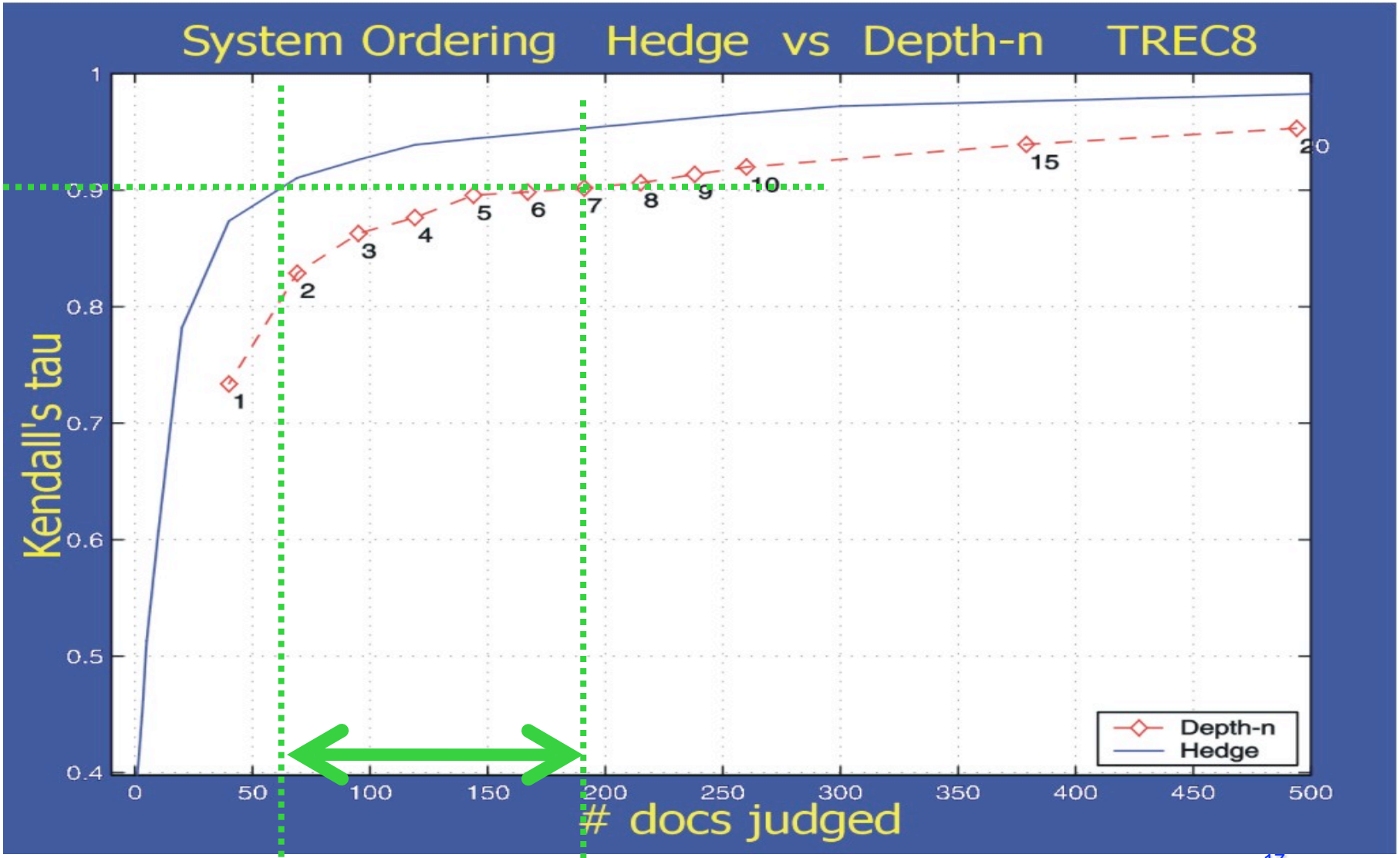
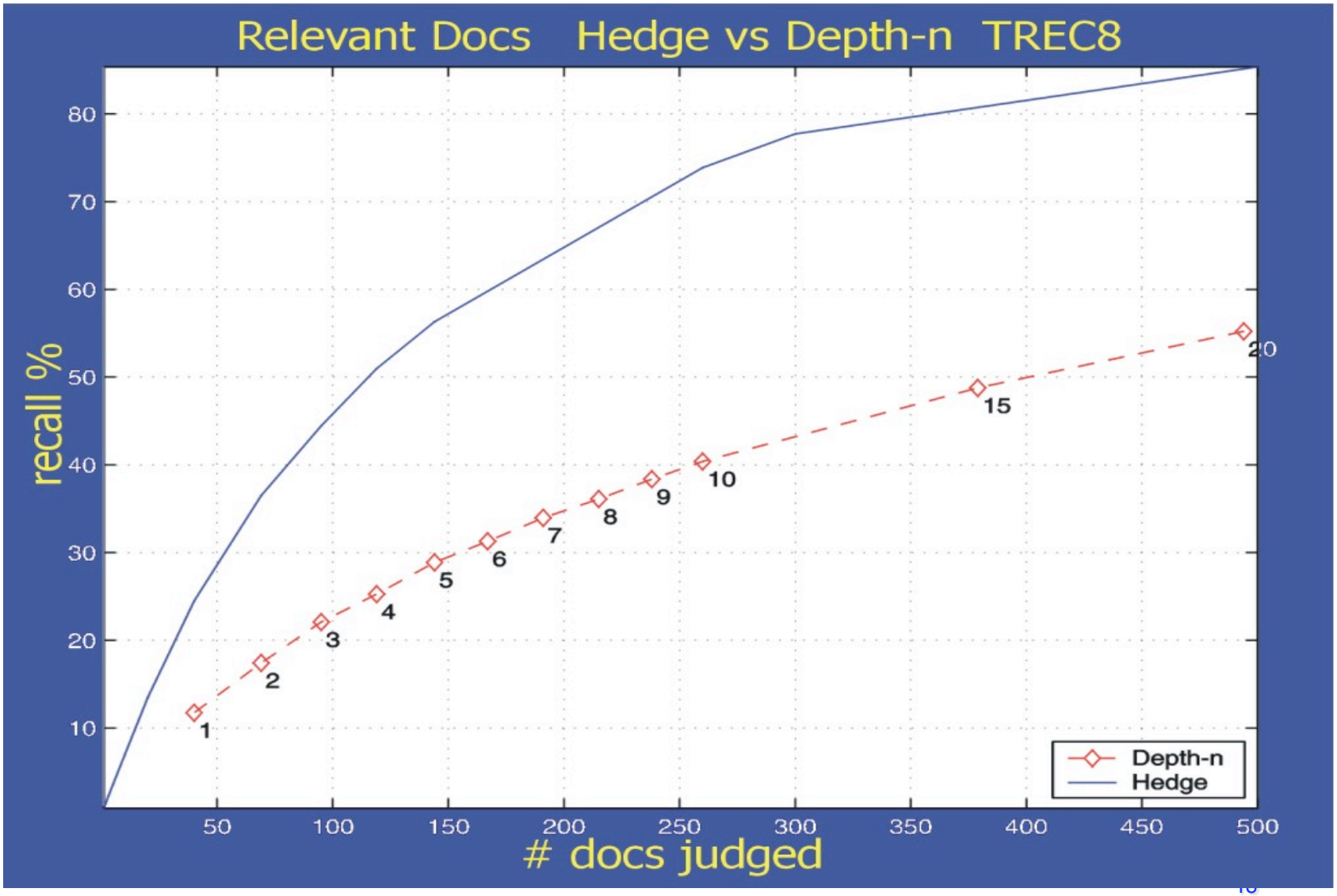


system evaluation – kendall's tau



experiments - relevant docs found



metasearch - no feedback (yet)

TREC	MNZ	COND	Hedge-0	%MNZ	%COND
3	0.423	0.403	0.418	-0.012	+0.037
5	0.294	0.307	0.309	+0.051	+0.006
6	0.341	0.315	0.345	+0.012	+0.095
7	0.320	0.308	0.323	+0.009	+0.049
8	0.350	0.343	0.352	+.0014	+0.026

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metasearch - no feedback (yet)

no relevant judgements

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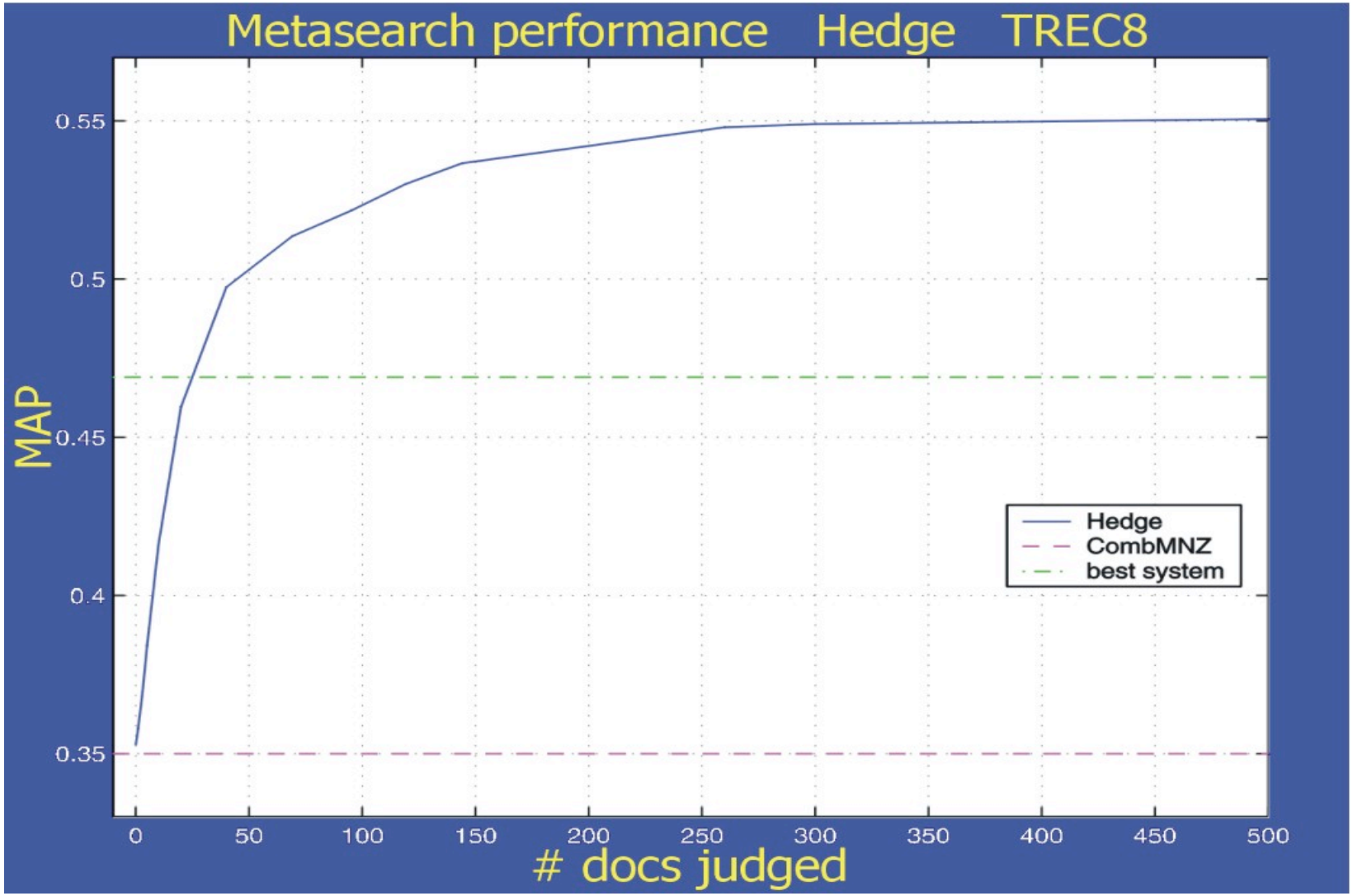
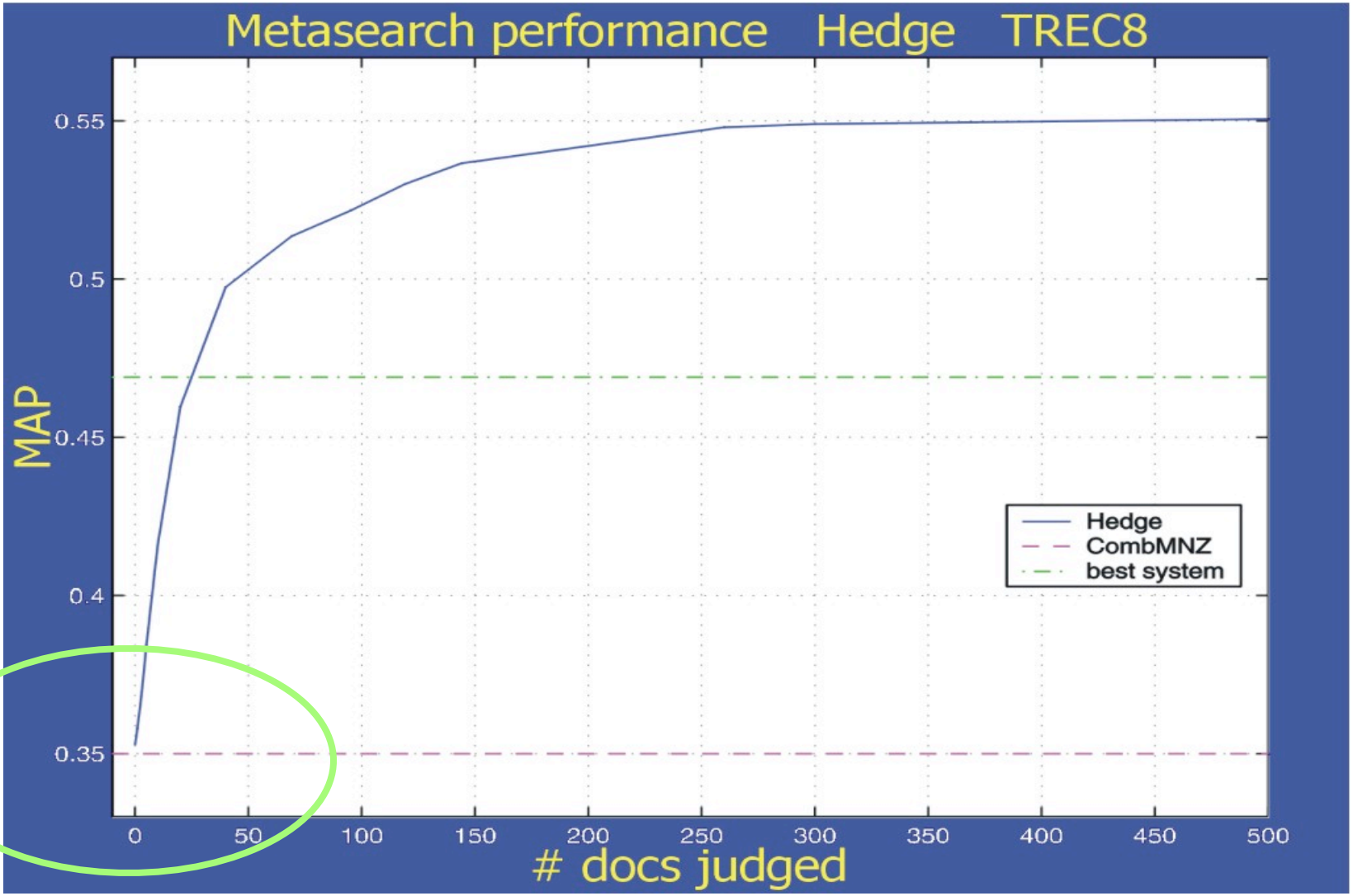
experiments - metasearch



experiments - metasearch



conclusion

- A powerful machine learning approach
  - Hedge = AdaBoost core
- Works [usually] better than anything else we've seen
- True, it uses feedback
  - But without feedback there are provable limitations
- It is missing a rigorous analysis
  - We are not very far away with that
  - Need a model assumption

differentiate (clasify) the search engines

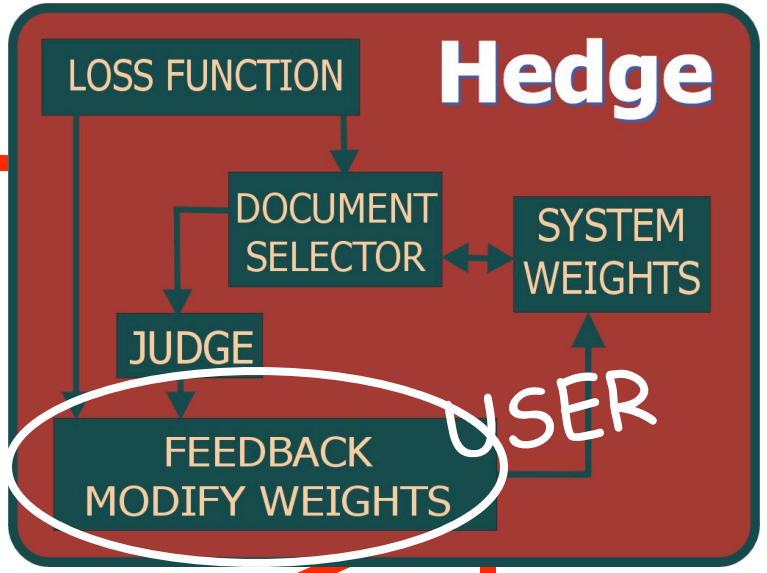
RANK	SYS1	SYS2	SYS3	SYS129
1	8	111	2	1013
2	2	2	821	466
3	1	4	134	84
4	134	7284	9725	5
5	14215	769	106	2038
6	24	84	439	4
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
1000	8521	11003	84	3967

84=RELEVANT 821=NON RELEVANT

SYSTEM	ORDERING(MAP)
READWARE2	0.469245750504929
orcl99man	0.413044919590457
iit99ma1	0.410361163615777
READWARE	0.400062083026587
CL99XTopt	0.376552749280167
CL99XT	0.373043274256318
CL99SDopt1	0.368216861184875
CL99SD	0.353710984082113
CL99SDopt2	0.351955930155801
8manexT3D1N0	0.334646677365296
pir9Aatd	0.330293582307575
ok8alx	0.324046294809153
Flab8atdn	0.323972048518037
MITSLStdn	0.32268558626124
pir9Attd	0.320651128642633
ok8amxc	0.31687789001205
att99atde	0.316549112790725
Flab8ax	0.316270864248346
apl8p	0.315425192468865
apl8c221	0.314991172213836
UniNET8Lg	0.313842898958697
apl8c621	0.312624929467966
fub99tt	0.310608000938879
fub99tf	0.309923242027166
att99atdc	0.308935872304471
fub99a	0.306768289435422
GE8MTD2	0.306560441783452
fub99td	0.306376965574526
pir9At0	0.306288595615414
pir9Atd0	0.302238406288713

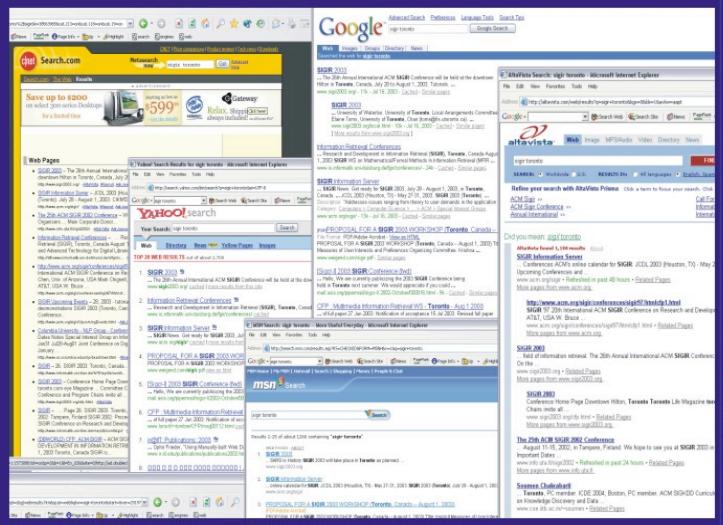
TREC8 competition
129 search engines (systems)
~1000 docs returned /query
TREC Evaluation DEPTH 100
-judge top 100 docs (each sys); use MAP to rank systems

the big picture



fuse the lists (metasearch)

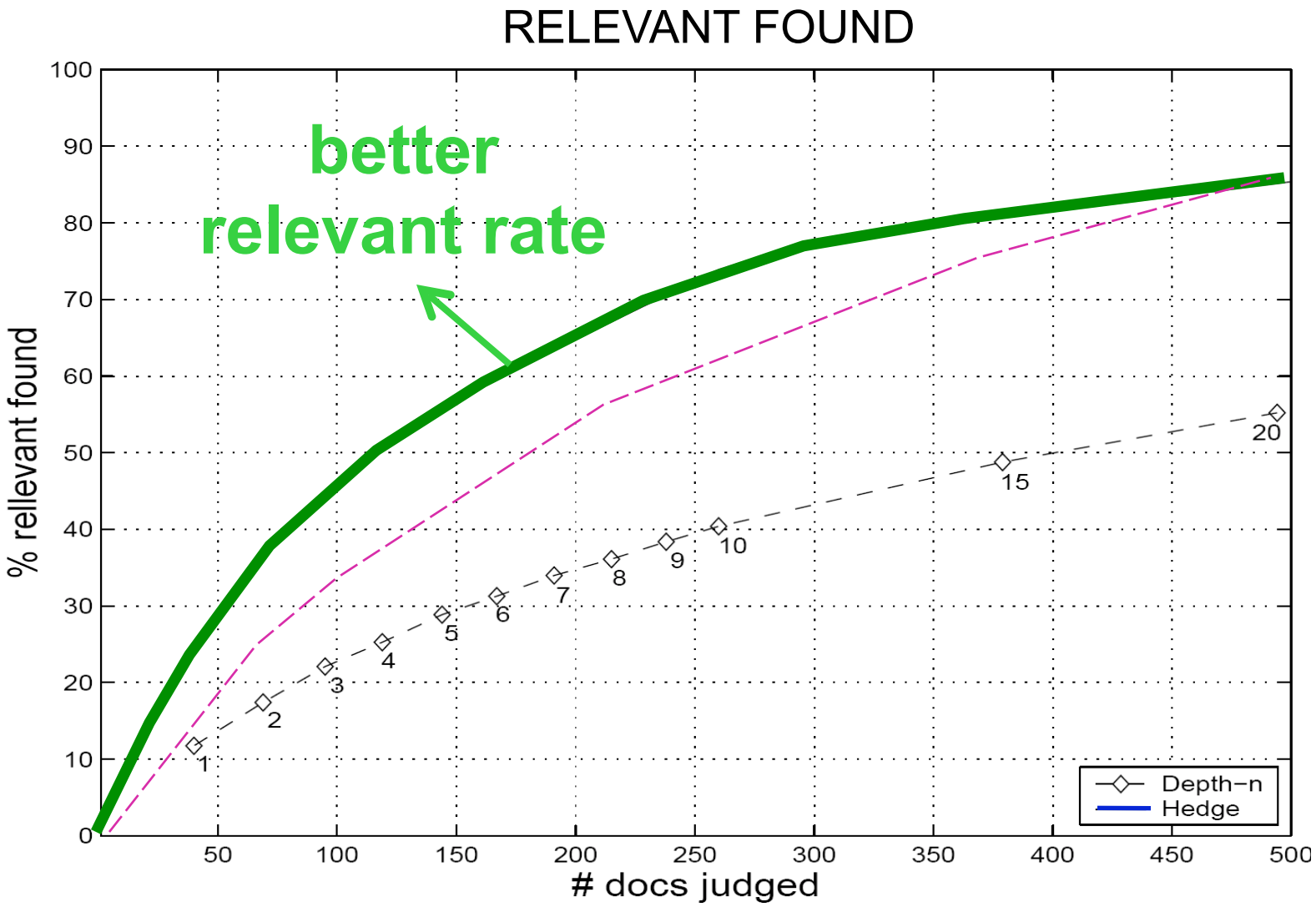
toronto sigir Search



metasearch list

1 SIGIR 2003
2 Information Retrieval Conferences
3 SIGIR Information Server
4 SIGIR Upcomming events
5 PROPOSAL FOR A SIGIR 2003 WORKSHOP
6 Andreas S. WEIGEND, PhD
7 [Sigcr-l] 2003 SIGIR Conference -
8 CFP : Multimedia Information Retrieval
9 The 25th ACM SIGIR 2002 Conference
10 Mark Girolami's home page -
11 Conferences on Information Retrieval
12 OntoWeb - SIGIR 2003 -2003-01-
13 Yahoo! Groups : webir Messages
14 DBWorld Message /2002-
15 Publications and Presentations of Thomas
16 SIGIR 2003 Workshop on the Evaluation
17 David Crow: Upcoming Conferences
18 Upcoming conferences for the WUME Lab
19 SIGIR 99 Preliminary Program
20 SIGIR 99 CFP/PC
21 Mounia Lalmas's list of activities
22 A Partial List of Publications of Hongyuan
23 ACM SIGIR 2002 Tutorial Bibliography
24 SIGIR <http://www.informatik.uni-
25 Information Retrieval Links
26 iSchool Events

KEY:
FIND RELEVANT DOCS


RELEVANT FOUND
better
relevant rate
% rellevant found
# docs judged
Depth−n
Hedge
0
10
20
30
40
50
60
70
80
90
100
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