Link-Based Similarity Search to Fight Web Spam

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Contents

Brief recap of link-spam

- Honest links [Chakrabarti et al., 1999]:

  "hyperlink structure contains an enormous amount of latent human annotation that can be extremely valuable for automatically inferring notions of authority"

- High revenue for top search engine ratings
- Manipulations, "Search Engine Optimization"
  - content spam
  - link spam – focus of the talk

Personalized PageRank, TrustRank, BadRank

Definition: random surfer with *teleportation distr.* r

$$\mathrm{PPR}_r(u) = c \cdot r(u) + (1-c) \sum_{vu \in E} \mathrm{PPR}_r(v)/d^+(v)$$

- TrustRank [Gyöngyi et al., VLDB 2004]
  - Personalizes on trusted pages
  - Propagates trust forward
  - Needs very carefully selected trusted hub set
- BadRank [Google folklore]
  - Penalizes by personalization on known spam
  - Propagates distrust backwards

TrustRank, BadRank Cont'd

Different schemes for trust and distrust splitting and aggregation [Wu et al., MTW 2006]

- splitting: equal, constant, logarithm
- aggregation: simple, maximum, maximum parent
- combining trust and distrust

Contents

How to Detect Spam with Similarity Search?

- Algorithms produce top list of similar pages
- Extract features based on the known spam and honest hosts in the list
- Impose threshold on the features
  - different threshold - different quality
  - decreasing threshold - increasing recall
- Precision-recall curves

Spam Thresholds by Similarity Top Lists

- Similarity top list size: k
- Honest from evaluation sample in top list: h
  sum of their similarity value: h^*
- Spam from evaluation sample in top list: s
  sum of their similarity value: s^*
- In general $h + s < k$

SR	Spam Ratio: $s/(s+h)$
SoN	Spam over Non-spam: s/h
SVR	Spam Value Ratio: $s^*/(s^*+h^*)$
SVoNV	Spam Value over Non-spam Value: s^*/h^*

Algorithms

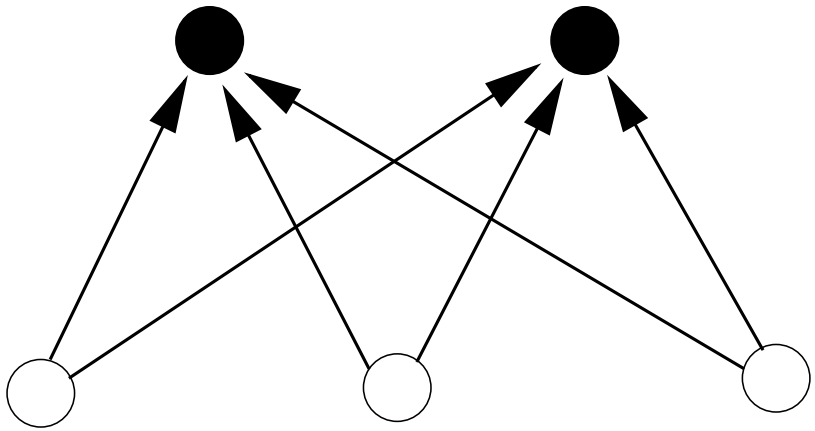
- Baseline algorithms
  - BadRank (distrust propagation)
  - Distrust propagation with different splitting and aggregation methods
  - Combined trust and distrust propagation
- Similarity algorithms
  - Cocitation
  - Companion
  - SimRank

  For each similarity algorithm compute the 4 features (SR, SoN, SVR, SVoNV)

Cocitation

Definition: Cocitation of a and b is the number of nodes that link to both a and b

- Easy to compute
- Easy to manipulate for spammers



SimRank

"Two pages are similar if referenced by similar pages" [Jeh–Widom KDD 2002]:

$$\mathrm{Sim}^{(0)}(u_1, u_2) = \begin{cases} 0 & \text{if } u_1 \neq u_2 \\ 1 & \text{if } u_1 = u_2 \end{cases}$$

$$\mathrm{Sim}^{(k)}(u_1, u_2) = \begin{cases} (1-c) \sum_{(v1,u1),(v2,u2)\in E} \dfrac{\mathrm{Sim}^{(k-1)}(v_1, v_2)}{d^-(u_1) \cdot d^-(u_2)} & \text{if } u_1 \neq u_2 \\ 1 & \text{if } u_1 = u_2 \end{cases}$$

- Similar to PageRank
- Generalization of cocitation
- Hard to manipulate
- Efficient algorithms [SBCsFR 2006]

HITS, Companion and the TKC effect

- Hypertext Induced Topic Search (HITS) [Kleinberg, 1999]
  - Finds good hub and authority pages
  - Hub and Authority scores in the vicinity of seed page(s)
  - Known to be vulnerable to Tightly Knit Communities (TKC)
- Companion [Dean–Henzinger, 1999]
  - Finds related pages
  - Performs HITS in the 2-step alternating neighborhood

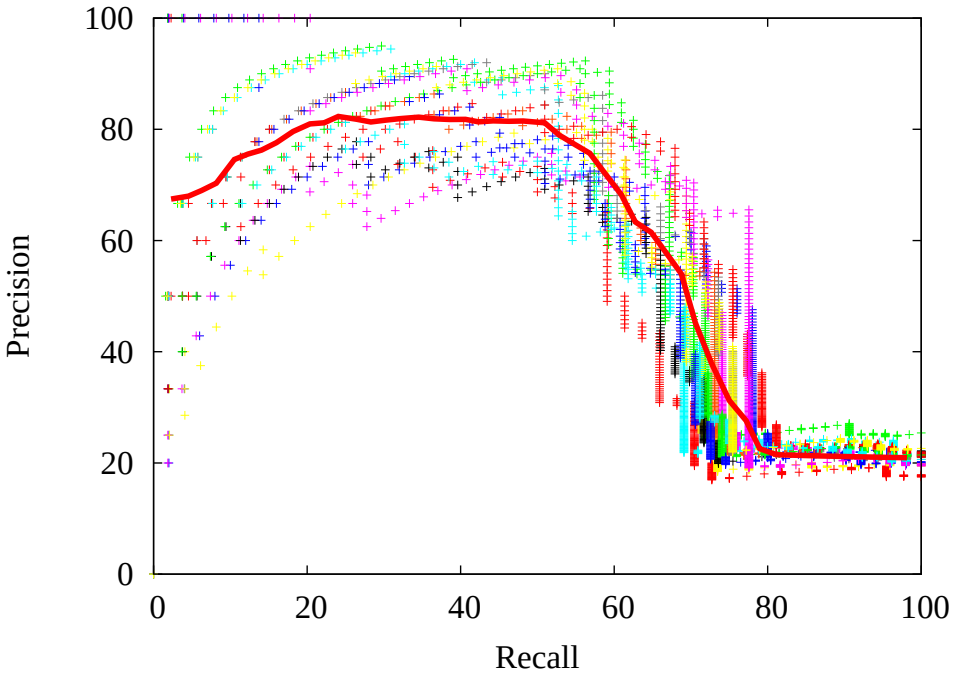
Outline

Evaluation Data Sets

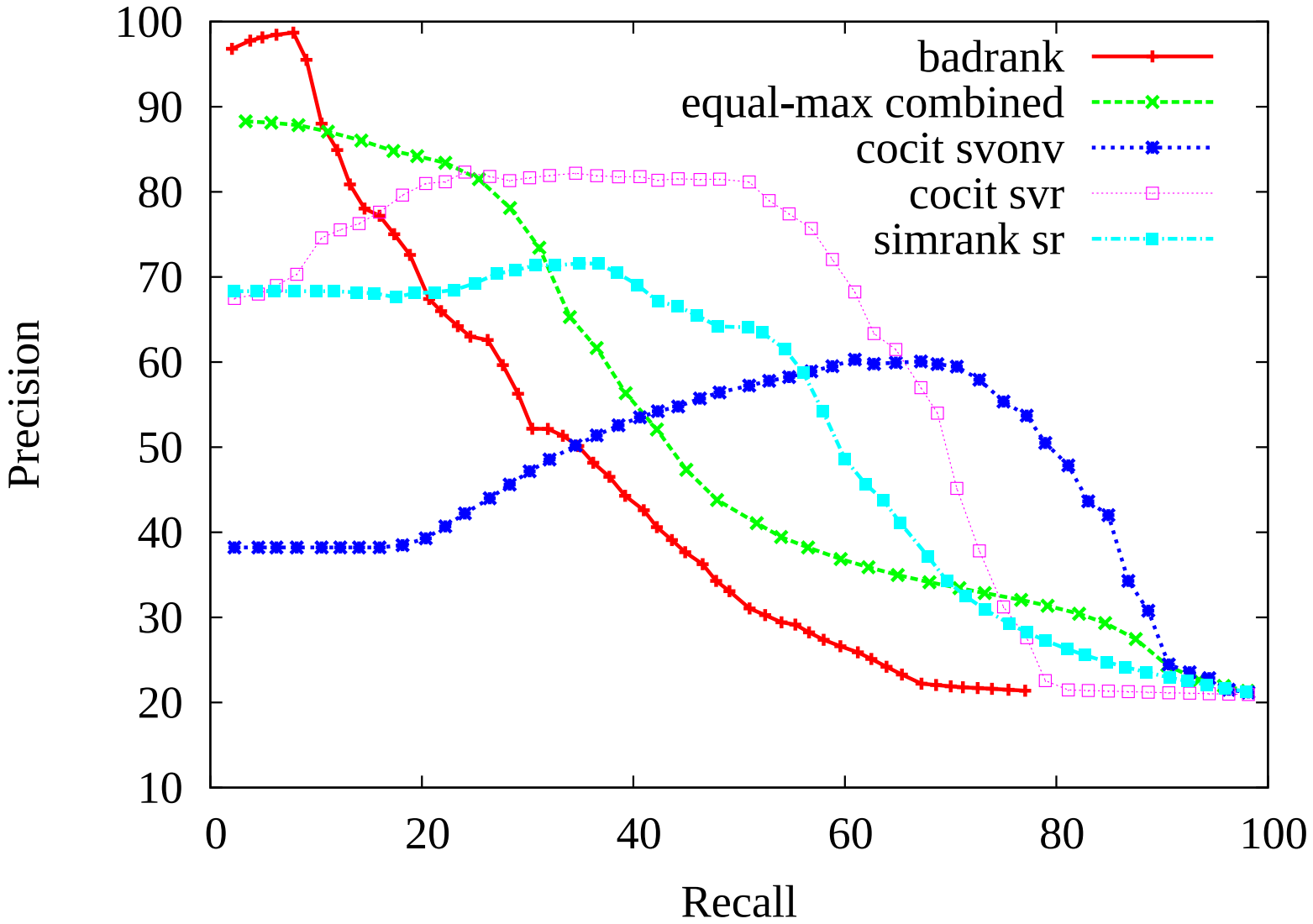
- `.de` domain
  - courtesy of T. Suel
  - 31M pages, 1B edges $\longrightarrow$ 800K sites, 25M edges
  - manually evaluated 1000-page sample with bias towards large PageRank
  - sample contains 20% spam
- `search.ch` data
  - courtesy of U. Müller
  - 20M pages, $\longrightarrow$ 300K domains, 24M edges
  - proprietary blacklist of `search.ch`
  - whitelist of B. Wu and B. Davison (Swiss ODP)
  - labeled set contains 4% spam

Evaluation Methodology

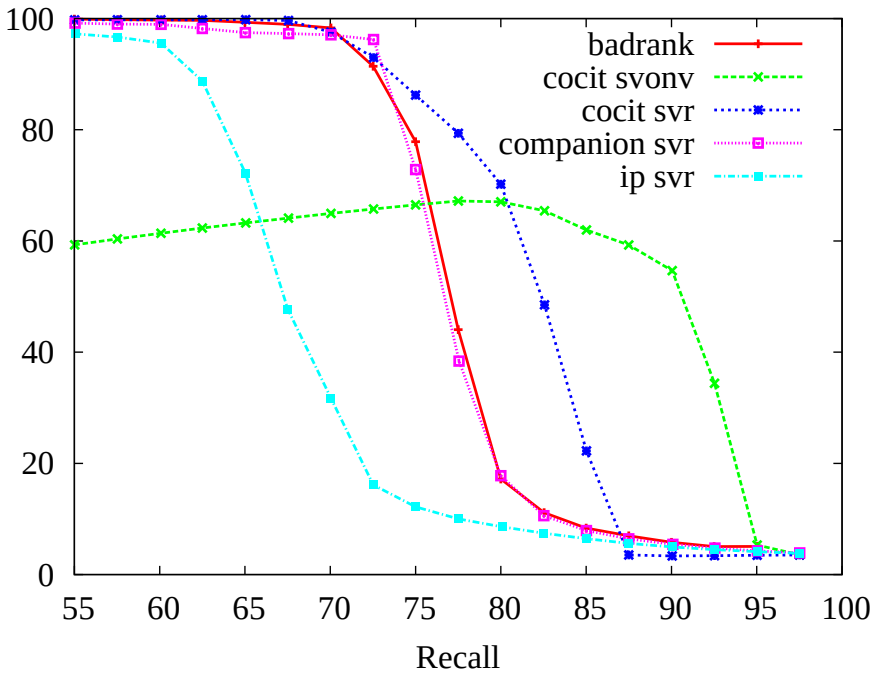
- 3-fold crossvalidation
- repeated 5 times with random splits
- Large variance in 15 results
- Averaging by interpolations of precision for all recall values



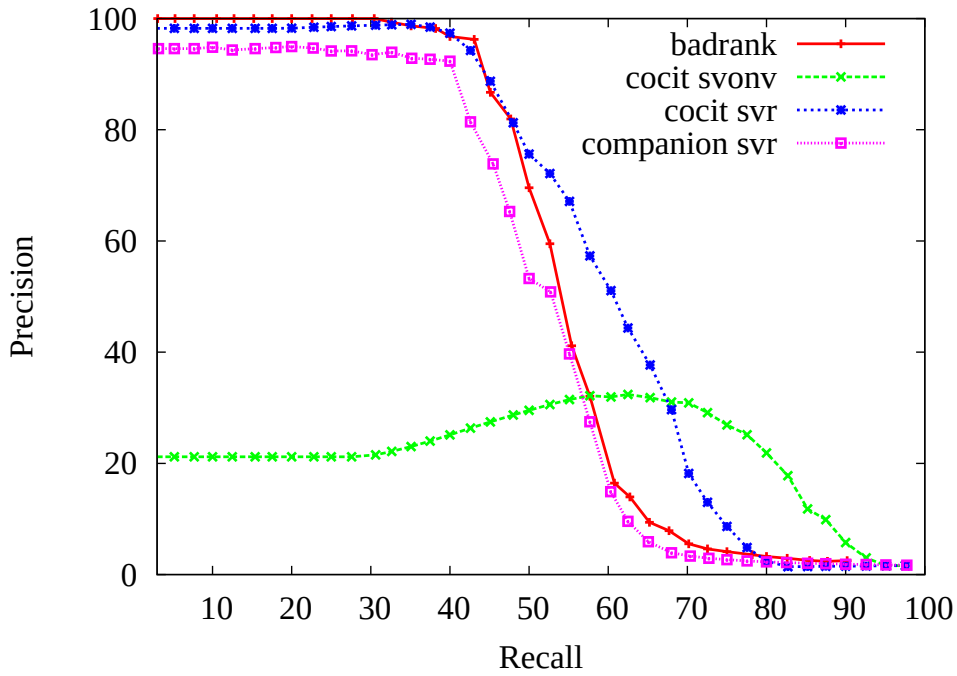
Results on the .de domain



Results on the search.ch data



Original sample



Reduced sample with unique IPs

Conclusion

- Link similarity based single feature classification
  - Capable of learning the difference between spam and nonspam
  - Better precision at higher recall than trust/distrust propagation
- Need for better data set
  - Uncorrelated spam pages
  - Good quality trusted set
- Future work
  - Further similarity algorithms
  - Use as input to classifiers
  - Use similarity algorithms to propagate output of other predictors along links

Thank you!

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