MARS: Applying Multiplicative Adaptive User Preference Retrieval to Web Search

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Outline of Presentation

- Introduction -- the vector model over R+
- Multiplicative adaptive query expansion algorithm
- MARS -- meta-search engine
- Initial empirical results
- Conclusions

Introduction

- Vector model
  - A document is represented by the vector **d** = (*d1*, … *dn*) where *di*'s are the relevance value of i-th index
  - A user query is represented by **q** = (q1,…,qn) where qi's are query terms
  - Document **d**' is preferred over document **d** iff **q•d** < **q•d**'

Introduction -- continued

- Relevance feedback to improve search accuracy
  - In general, take user's feedback, update the query vector to get closer to the target
    $\mathbf{q}(k+1) = \mathbf{q}(k) + \mathbf{a}1 \bullet \mathbf{d}1 + \ldots + \mathbf{a}s \bullet \mathbf{d}s$
  - Example: relevance feedback based on similarity
  - Problem with linear adaptive query updating: converges too slowly

Multiplicative Adaptive Query Expansion Algorithm

- Linear adaptive yields some improvement, but it converges to an initially unknown target too slowly
- Multiplicative adaptive query expansion promotes or demotes the query terms by a constant factor in i-th round of feedback
  - promotes: $q(i,k+1) = (1+f(d)) \bullet q(i,k)$
  - demotes: $q(i, k+1) = q(i,k)/(1+f(d))$

MA Algorithm -- continue

```
while (the user judged a document d)
{
   for each query term in q(k)
      if (d is judged relevant)          // promote the term
         q(i,k+1) = (1+f(di)) • q(i,k)
      else if (d is judged irrelevant) // demote the term
         q(i, k+1) = q(i,k) / (1+f(di))
      else      // no opinion expressed, keep the term
         q(i, k+1) = q(i, k)
}
```

MA Algorithm -- continue

- The f(di) can be any positive function
- In our experiments we used

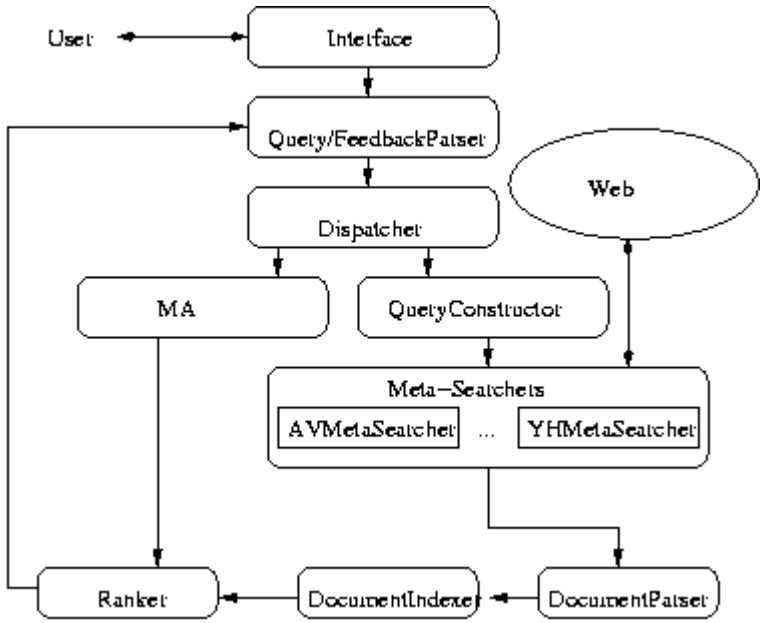
  $$f(x) = 2.71828 \cdot weight(x)$$

- where x is a term appeared in di
- We have detailed analysis of the performance of the MA algorithm in detail in another paper
- Overall, MA performed better than linear additive query updating such as Rocchio's similarity based relevance feedback in terms of time complexity and search accuracy
- In this paper we present some experiment results

The Meta-search Engine MARS

- We implemented the algorithm MARS in our experimental search engine
- The meta-search engine has a number of components, each of which is implemented as a module
- It is very flexible to add or remove a component

The Meta-search Engine MARS
-- continue



The Meta-search Engine MARS
-- continue

- User types a query into the browser
- The QueryParser sends the query to the Dispatcher
- The Dispatcher determines whether this is an original query, or a refined one
- If it is the original, send the query to one of the search engines according to user choice
- If it is a refined one, apply the MA algorithm

The Meta-search Engine MARS
-- continue

- The results either from MA or directly from other search engines are ranked according to the scores based on similarity
- The user can mark a document relevant or irrelevant by clicking the corresponding *radio button* at the MARS interface
- The algorithm MA refines document ranking by either promoting or demoting the query term

Search Engine - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites History

Address http://www.eg.bucknell.edu/~xmeng/mars/mars.html Go Links

mars Search words 40 Number of URLS

AltaVista Excite GoTo HotBot

InfoSeek(GO) Lycos Northern Light Yahoo

Search

Done Internet

File Edit View Favorites Tools Help

Back Search Favorites History

Address http://www.eg.bucknell.edu/cgi-bin/cgiwrap/xmeng/mars/start Go Links

Search Words Search

Relevant?			Good Matches
○ yes	● no	40.000	http://www.mars.com/
● yes	○ no	39.000	http://mars.jpl.nasa.gov/
● yes	○ no	38.000	http://pds.jpl.nasa.gov/planets/welcome/mars.htm
○ yes	○ no	37.000	http://www.cwmars.org/
○ yes	○ no	36.000	http://www.marssociety.org/
○ yes	○ no	35.000	http://www.solarviews.com/eng/mars.htm
○ yes	○ no	34.000	http://www.seds.org/nineplanets/nineplanets/mars.h
○ yes	○ no	33.000	http://www.seds.org/~spider/mars/mars.html
○ yes	○ no	32.000	http://oposite.stsci.edu/pubinfo/pr/97/15.html
○ yes	○ no	31.000	http://www.broadsword.com/mp/mpmain.shtml

Relevant?			Bad Matches
○ yes	○ no	1.000	http://www.marsandco.com/
○ yes	○ no	2.000	http://www.digitalmars.com/
○ yes	○ no	3.000	http://www.spaceref.com/mars/
○ yes	○ no	4.000	http://www.marssociety.be/
○ yes	○ no	5.000	http://mars-sim.sourceforge.net/
○ yes	○ no	6.000	http://www.mars.org.uk/
○ yes	○ no	7.000	http://www.catsarefrommars.com/
○ yes	○ no	8.000	http://www.marshill.org/
○ yes	○ no	9.000	http://mars.nl/
○ yes	○ no	10.000	http://www.mars.nl/

feedback

showAll

File Edit View Favorites Tools Help

Back Search Favorites History

Address http://www.eg.bucknell.edu/cgi-bin/cgiwrap/xmeng/mars/yesno Go Links

Search Words Search

Relevant?			Good Matches
yes	no	1.000	http://pds.jpl.nasa.gov/planets/welcome/mars.htm
yes	no	0.931	http://mars.jpl.nasa.gov/
yes	no	0.380	http://oposite.stsci.edu/pubinfo/pr/97/15.html
yes	no	0.350	http://www.navymars.org/
yes	no	0.321	http://www.broadsword.com/mp/mpmain.shtml
yes	no	0.291	http://mars-sim.sourceforge.net/
yes	no	0.291	http://www.marsmusic.com/
yes	no	0.282	http://www.a-ten.com/alz/mars.htm
yes	no	0.278	http://www.mhc.edu/
yes	no	0.265	http://www.catsarefrommars.com/

Relevant?			Bad Matches
yes	no	0.000	http://www.mars.com/
yes	no	0.039	http://www.mars2030.net/
yes	no	0.042	http://www.marsandco.com/
yes	no	0.078	http://marsartifacts.tripod.com/
yes	no	0.082	http://www.marssociety.be/
yes	no	0.082	http://www.m-a-r-s.de/
yes	no	0.084	http://www.iki.rssi.ru/mars96/mars96hp.html
yes	no	0.115	http://mars.nl/
yes	no	0.116	http://mars.reefkeepers.net/
yes	no	0.121	http://marsattacks.warnerbros.com/

feedback

showAll

Initial Empirical Results

- We conducted two types of experiments to examine the performance of MARS
- The first is the response time of MARS
  - The initial time retrieving results from external search engines
  - The refine time needed for MARS to produce results
  - Tested on a SPARC Ultra-10 with 128 M memory

Initial Empirical Results --continue

- Initial retrieval time:
  - mean: 3.86 seconds
  - standard deviation: 1.15 seconds
  - 95% confidence interval 0.635
  - maximum: 5.29 seconds
- Refine time:
  - mean: 0.986 seconds
  - standard deviation: 0.427 seconds
  - 95% confidence interval: 0.236
  - maximum: 1.44 seconds

Initial Empirical Results --continue

- The second is the search accuracy improvement
  - define
    - A: total set of documents returned
    - R: the set of relevant documents returned
    - Rm: set of relevant documents among top-m-ranked
    - m: an integer between 1 and |A|
    - recall rate = |Rm| / |R|
    - precision = |Rm| / m

Initial Empirical Results --continue

- randomly selected 70+ words or phrases
- send each one to AltaVista, retrieving the first 200 results of each query
- manually examine results to mark documents as relevant or irrelevant
- compute the precision and recall
- use the same set of documents for MARS

Initial Empirical Results --continue

Recall	(200, 10)	(200, 20)	Precision	(200,10)	(200,20)
AltaVista	0.11	0.19		0.43	0.42
MARS	0.20	0.25		0.65	0.47

Initial Empirical Results --continue

- Results show that the extra processing time of MARS is not significant, relative to the whole search response time
- Results show that the search accuracy is improved by in both recall and precision
- General search terms improve more, specific terms improve less

Conclusions

- Linear adaptive query update is too slow to converge
- Multiplicative adaptive is faster to converge
- User inputs are limited to a few iterations of feedback
- The extra processing time required is not too significant
- Search accuracy in terms of precision and recall is improved