Studying Trailfinding Algorithms for Enhanced Web Search

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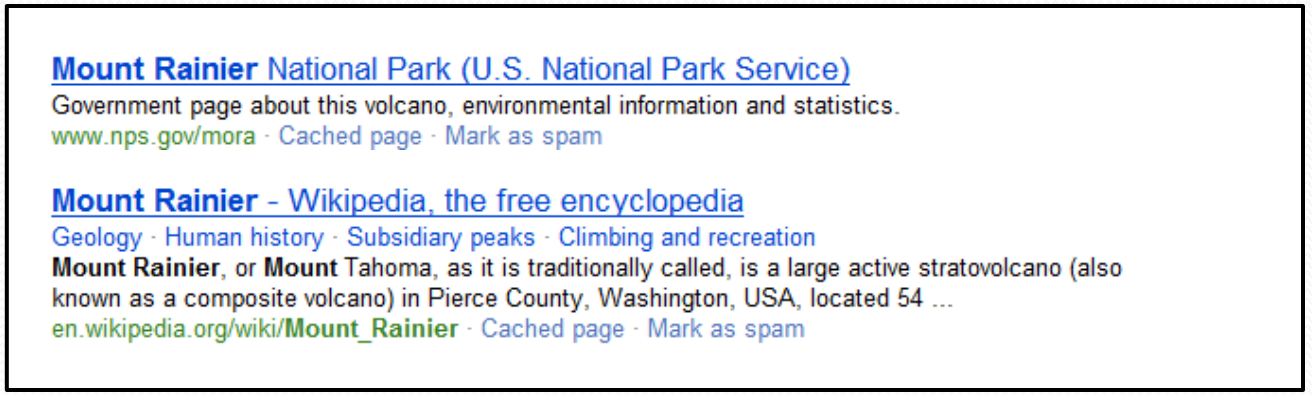
IR Focused on Document Retrieval

- Search engines usually return lists of documents



- Documents may be sufficient for known-item tasks
- Documents may only be starting points for exploration in complex tasks
  - See research on orienteering, berrypicking, etc.

Beyond Document Retrieval

- Log data lets us study the search activity of many users
  - Harness wisdom of crowds
  - Search engines already use result clicks extensively
- Toolbar logs also provide non-search engine activity
  - **Trails** from these logs might help future users
  - Trails comprise queries and post-query navigation
- IR systems can return documents *and*/*or* trails
  - **The "trailfinding" challenge**

Trailfinding

- Trails can provide guidance to users beyond the results
- Trails can be shown on search result page, e.g.,

Mount Rainier National Park (U.S. National Park Service)
Government page about this volcano, environmental information and statistics.
http://www.nps.gov/mora/ → http://www.nps.gov/mora/planyourvisit/index.htm → http://www.nps.gov/mora/planyourvisit/things2know.htm → http://www.nps.gov/mora/planyourvisit/yoursafety.htm → http://www.nps.gov/mora/planyourvisit/wheretoeat.htm → http://www.nps.gov/mora/planyourvisit/directions.htm → http://usasearch.gov/search?affiliate=nps&v:project=firstgov&input-form=simple-firstgov&query=site:nps.gov/mora+toll&query_tmp=toll&alphaCode=mora → http://www.nps.gov/mora/planyourvisit/hours.htm → http://www.nps.gov/mora/planyourvisit/feesandreservations.htm → http://www.nps.gov/mora/planyourvisit/educational-fee-waiver.htm

Mount Rainier - Wikipedia, the free encyclopedia
Mount Rainier is a large active stratovolcano (also known as a composite volcano) in Pierce County, Washington, USA, located 54 miles (87 km) southeast of Seattle.
http://en.wikipedia.org/wiki/Mount_Rainier → http://en.wikipedia.org/wiki/Peter_Rainier,_junior → http://en.wikipedia.org/wiki/Stratovolcano → http://en.wikipedia.org/wiki/Popocatépetl → http://en.wikipedia.org/wiki/List_of_volcanoes_in_Mexico → http://en.wikipedia.org/wiki/Parícutin → http://en.wikipedia.org/wiki/Monogenetic_volcanic_field → http://en.wikipedia.org/wiki/Captain_from_Castile → http://en.wikipedia.org/wiki/Cinder_cone → http://en.wikipedia.org/wiki/Caldera

- How to select best trail(s) for each query-result pair?
  - We present a log-based method and investigation

Outline for Remainder of Talk

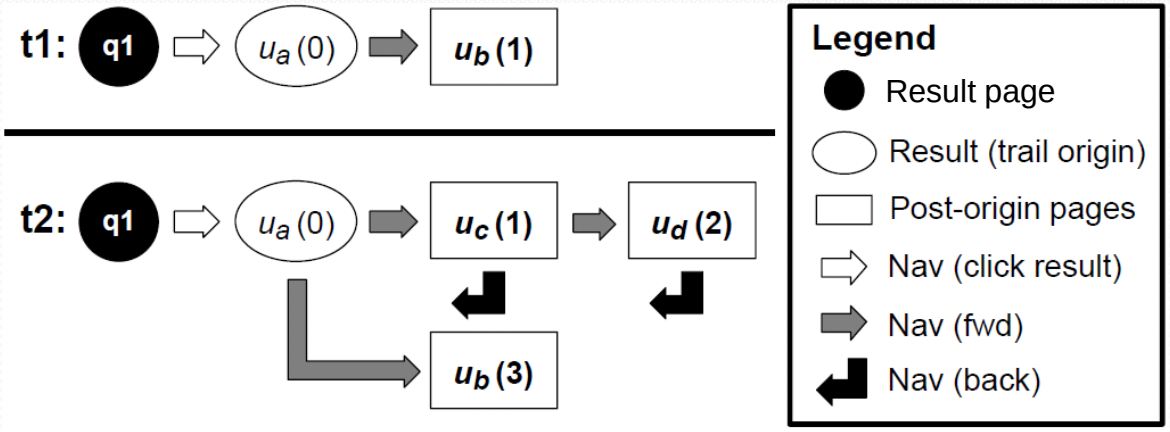
- Related work
- Trails
  - Mining Trails
  - Finding Trails
- Study
  - Methods
  - Metrics
  - Findings
- Implications

Related Work

- *Trails as evidence for search engine ranking*
  - *e.g.*, Agichtein et al., 2006; White & Bilenko, 2008; …
- *Step-by-step guidance for Web navigation*
  - *e.g.*, Joachims et al, 1997; Olston & Chi, 2003; Pandit & Olston, 2007
- *Guided tours (mainly in hypertext community)*
  - Tours are first-class objects, found and presented
  - Human-generated
    - *e.g.*, Trigg, 1988; Zellweger, 1989
  - Automatically-generated
    - *e.g.*, Guinan & Smeaton, 1993; Wheeldon & Levene, 2003

Trail Mining

- Trails sourced from nine months of MSN toolbar logs
- Search trails are initiated by search queries
  - Terminate after 10 actions or 30 minutes of inactivity
- Trails can be represented as Web behavior graphs



- Graph properties used for trailfinding

Trailfinding Algorithms

- Trailfinding task is defined as:

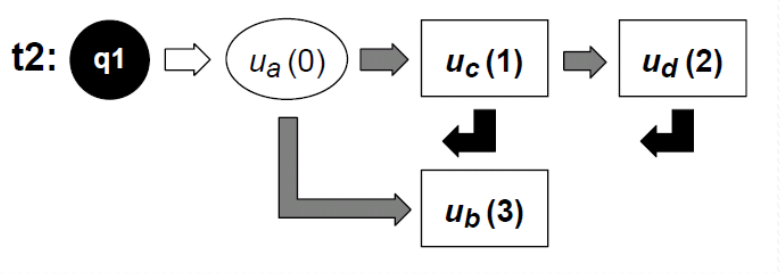
Given a query q and an observed click on a trail origin r, find the trail t in T with the largest $Score(t, q, r)$

- We can define $Score(t, q, r)$ in a number of ways …

$Score(t, q, r) =$

- Length
  - Number of nodes after origin r
- Breadth
  - Number of branches after r
- Depth
  - Maximum number of nodes on a single branch from origin r
- Frequency
  - Frequency of occurrence of trail t for query q and origin r
- Relevance

$$\left[\sum_{u_x \text{ in } t} Max(\%\ query\ terms\ in\ title_x, \%\ query\ terms\ in\ URL_x)\right] / Length(t)$$



$Score(t, q, r) =$

- Trail Diversity
  - Number of pages in t with different domain than origin r
- Trail Strength
  - Function of engaging potential of behavior graph and the ease of navigation between trail nodes
  - **Step 1:** Count overall frequency of each transition in t (over all trails)

$$(q, r, < u_x \rightarrow u_y >) = \sum_{u_x \rightarrow u_y \; in \; t} Freq(t, q, r)$$

  - **Step 2:** Score t based on sum of transition frequencies

$$= \sum_{u_x \rightarrow u_y \; in \; t} (u_x \rightarrow u_y, q, r)$$

Study: Research Qs

- *RQ1*: Of the trails and origins, which source: (i) provides more relevant information? (ii) provides more coverage and diversity of the query topic? (iii) provides more useful information?

- *RQ2*: Among trailfinding algorithms: (i) how does the value of best-trails chosen differ? (ii) what is the impact of origin relevance on best-trail value and selection? (iii) what are the effects of query characteristics on best-trail value and selection?

- *RQ3*: In associating trails to unseen queries: (i) how does the value of trails found through query-term matching compare to trails with exact query matches found in logs? (ii) how robust is term matching for longer queries (which may be noisy)?

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Study: Data Preparation

- Large random sample of queries from Bing logs
- Queries normalized, etc.
- Labeled trail pages based on Open Directory Project
  - Classification is automatic, based on URL with back-off
  - Coverage of pages is 65%, partial trail labeling is allowed
- Interest models were constructed for queries & trails
  - E.g., for query [triathlon training]:

Label	**Norm. Freq.**
Top/Sports/Multi_Sports/Triathlon/Training	0.58
Top/Sports/Multi_Sports/Triathlon/Events	0.21
Top/Shopping/Sports/Triathlon	0.11

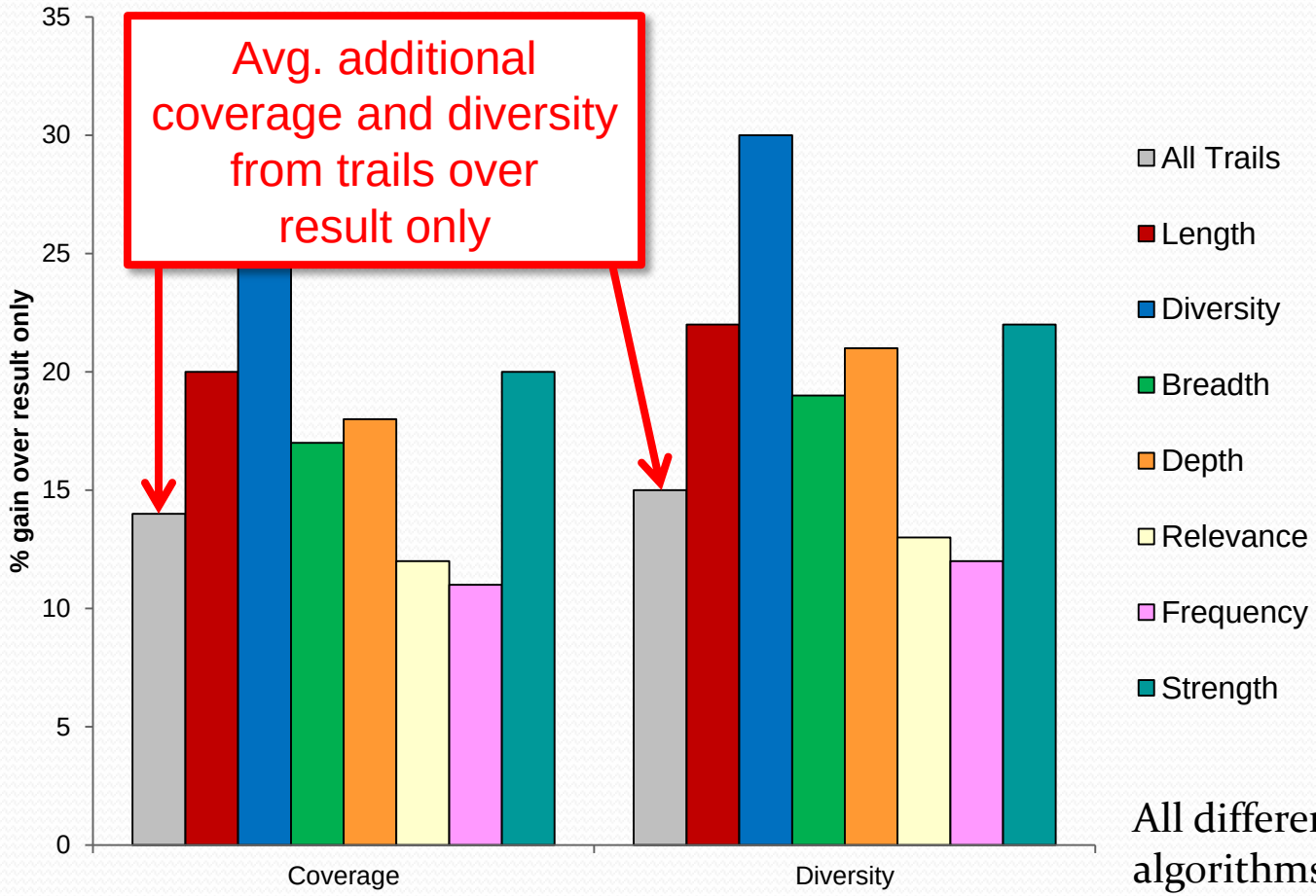
Study: Metrics

- Coverage
  - Query interest model built from top Goo/Yah/Bing results
  - Fraction of query interest model covered by trail
- Diversity
  - Fraction of unique query interest model labels in trail
- Relevance
  - Query-URL relevance scores from human judges (6pt scale)
  - Average relevance score of trail page(s)
- Utility
  - One if a trail page has dwell time of 30 seconds or more
    - Fox et al. (2005) showed dwell ≥ 30 secs. indicative of utility

Study: Method

- For each query-result pair:
  - Select the best trail using each trailfinding algorithm
  - Compute each of the metrics
- Split findings by origin relevance
  - Best – origin results with high relevance ratings
  - Worst – origin results with low relevance ratings
- Micro-averaged within each query and macro-averaged across all queries
  - Obtain a single value for each source-metric pair

Findings: Coverage/Diversity



All differences between algorithms were statistically significant ($p < .01$)

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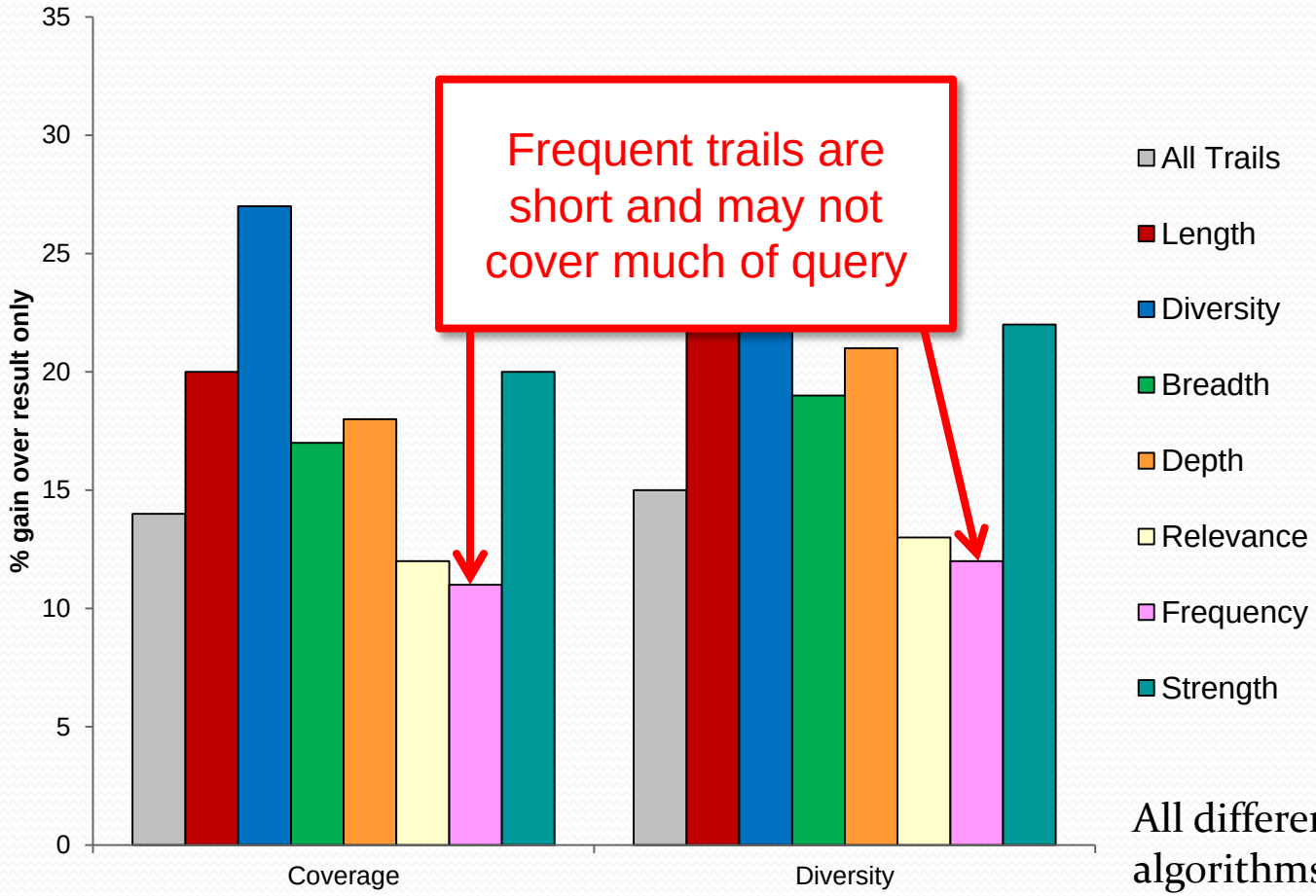

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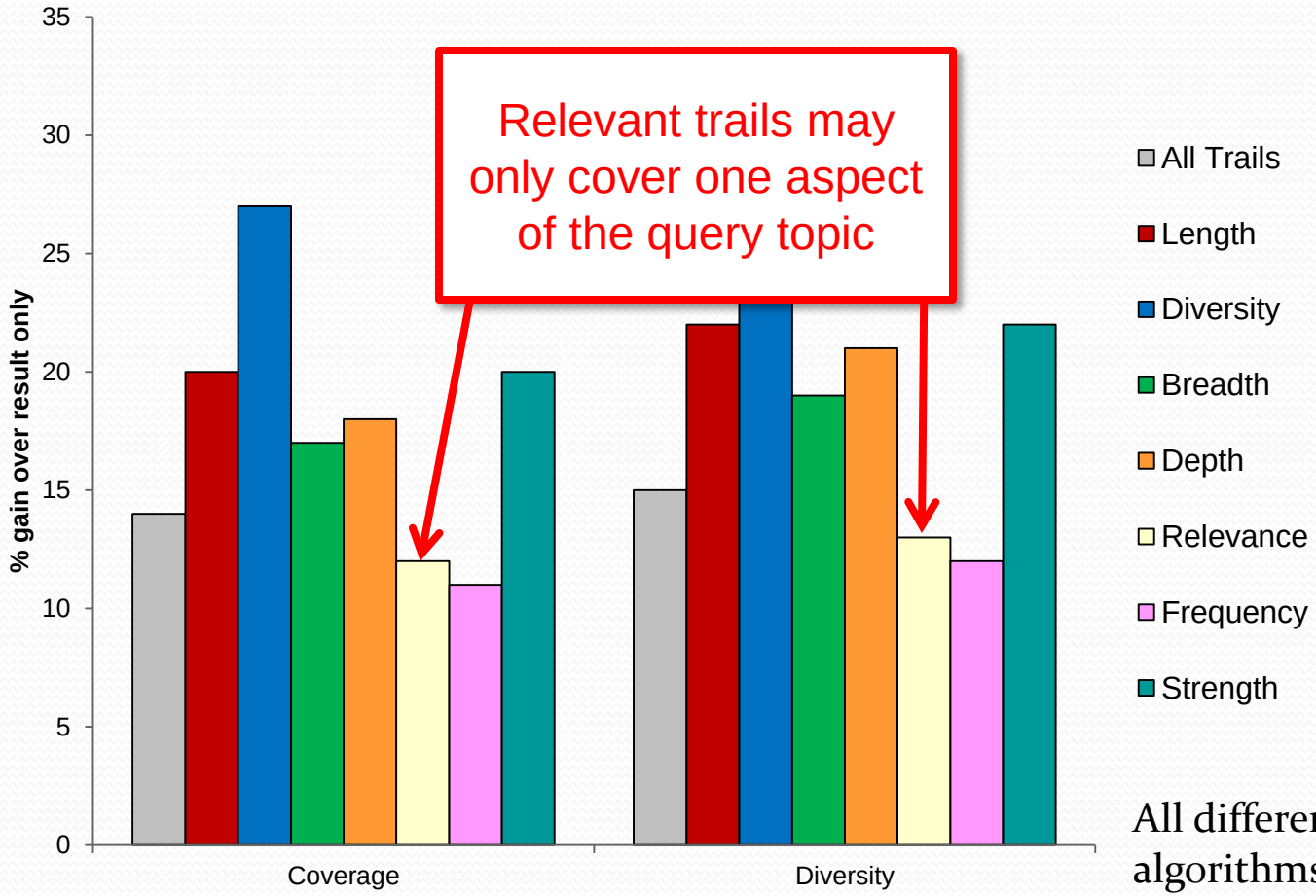

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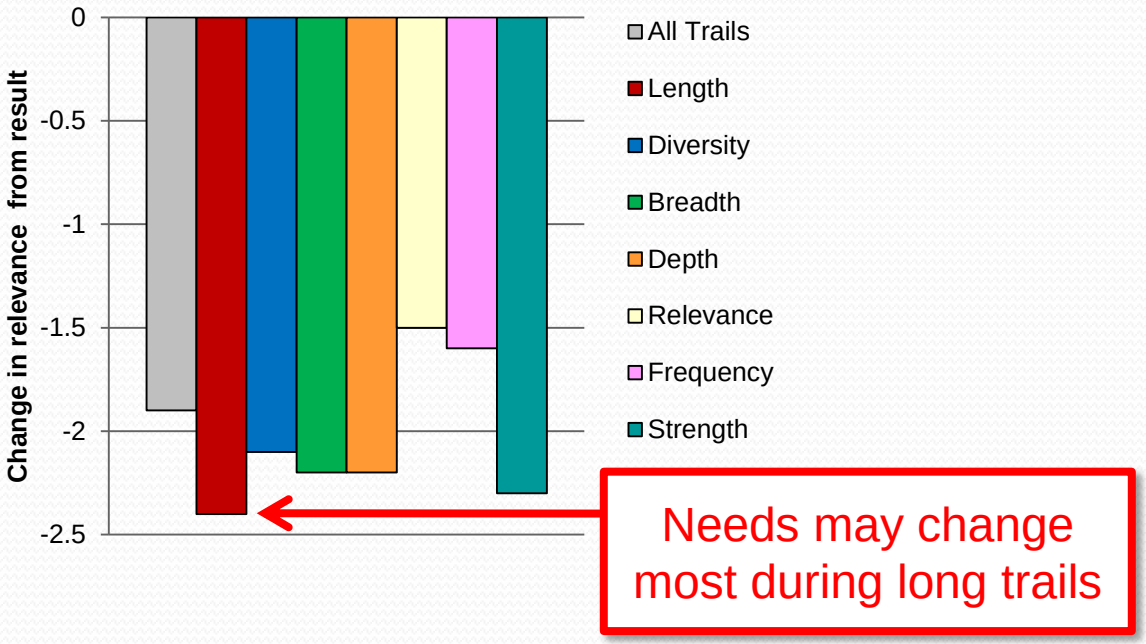
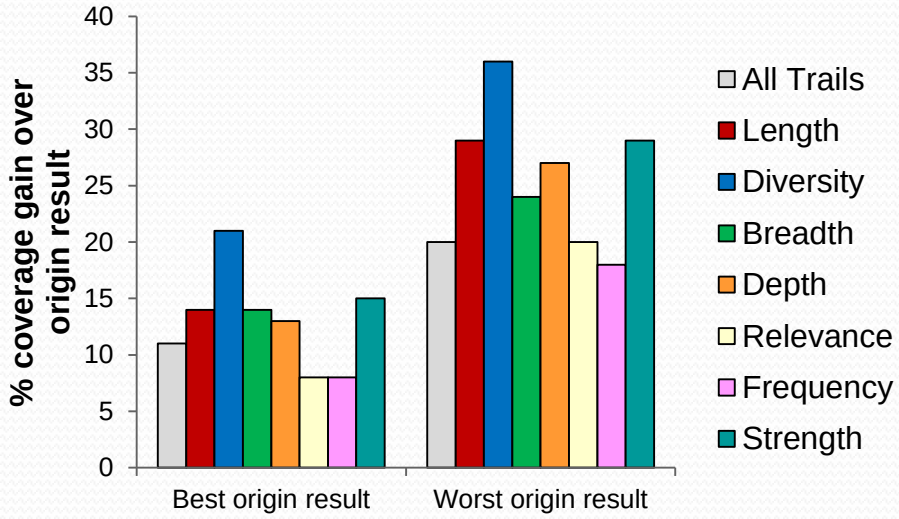
Findings: Avg. Relevance Scores



- Decreases rather than increases
- Relevance defined in relation to original query
  - Needs may evolve during trail following

Findings: Vary Origin Relevance

- Divided trail data into two buckets:
  - Best origins: trails with highest origin relevance
  - Worst origins: trails with lowest origin relevance



- Trails help most when initial search results are poor
- Trails may not be appropriate for all search results

Implications

- Approach has provided insight into what trailfinding algorithms perform best and when
- Next step: Compare trail presentation methods
- Trails can be presented as:
  - Alternative to result lists
  - Popups shown on hover over results
  - In each caption in addition to the snippet and URL
  - Shown on toolbar as user is browsing
- More work also needed on when to present trails
  - Which queries? Which results? Which query-result pairs?

Summary

- Presented a study of trailfinding algorithms
- Compared relevance, coverage, diversity, utility of trails selected by the algorithms
- Showed:
  - Best-trails outperform average across all trails
  - Differences attributable to algorithm and origin relevance
- Follow-up user studies and large-scale flights planned

- See paper for other findings related to effect of query length, trails vs. origins, term-based variants