Precision-Oriented Query Facet Extraction

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What are query facets?

baggage allowance

Facet 1
- AA
- Delta
- JetBlue

Facet 2
- Business
- Economy

Facet 3
- International
- Domestic
What are query facets?

<table>
<thead>
<tr>
<th>Facet 1</th>
<th>Facet 2</th>
<th>Facet 3</th>
</tr>
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<tbody>
<tr>
<td>AA</td>
<td>Business</td>
<td>International</td>
</tr>
<tr>
<td>Delta</td>
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<td>Domestic</td>
</tr>
<tr>
<td>JetBlue</td>
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</tr>
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</table>

- A list of terms in a semantic class
- One aspect/facet of the query
What are query facets?

- A list of terms in a semantic class
- One aspect/facet of the query

• Helps clarify search intent
• Assists faceted query and exploratory search
Query facet extraction

Step 1: apply patterns

<table>
<thead>
<tr>
<th>Candidate facets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Delta, Facebook, Login</td>
</tr>
<tr>
<td>2. AA, Delta, British Airways</td>
</tr>
<tr>
<td>3. JetBlue, first, business, economy</td>
</tr>
</tbody>
</table>

Step 2: refine facets

<table>
<thead>
<tr>
<th>Query Facets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AA, Delta, JetBlue, ...</td>
</tr>
<tr>
<td>2. international, domestic</td>
</tr>
<tr>
<td>3. weight, size, quantity</td>
</tr>
<tr>
<td>4. business, economy</td>
</tr>
</tbody>
</table>

[Kong & Allan SIGIR’13]
Query facet extraction

Step 1: apply patterns

1. Delta, Facebook, Login
2. AA, Delta, British Airways
3. JetBlue, first, business, economy
...

Step 2: refine facets

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<td>...</td>
<td>4. business, economy</td>
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</table>
Faceted search

1-60 of 27,637 results for Electronics: Computers & Accessories: Monitors: "computer monitor"

Refine by

Brand
- Dell
- ViewSonic
- HP
- Acer
  + See more

Display Technology
- LED-Lit (5,033)
- LCD (8,481)
- Curved (24)
- 4K UHD (98)

Condition
- New (25,681)
- Used (2,959)
- Refurbished (1,263)

HP Pavilion 21.5-Inch IPS LED HDMI VGA Monitor
- $99.99 $119.99
- Prime
- 4 stars
- 940

Acer G226HQL 21.5-Inch Screen LED Monitor
- $79.99 $129.99
- Prime
- #1 Best Seller in Computer Monitors
- 4 stars
- 3,657
Faceted search

Facets not available for the web
Using query facets to extend faceted search to the web

[Kong & Allan CIKM’14]

users select terms

Facet 1
- AA
- Delta
- JetBlue

Facet 2
- International
- Domestic

Facet 3
- Weight
- Size
- Quantity

Facet 4
- Business
- Economy

search for: baggage allowance

American Airlines Baggage Allowance Information
www.aa.com/i18n/.../baggage/baggageAllowance.jsp

Airline baggage allowance information from netflights
www.netflights.com

Delta Baggage | Baggage Fees | Delta Air Lines
www.delta.com/content/www/en_US/.../baggage.html

United Airlines - Baggage Information | Baggage Policy
www.gsa.gov

re-rank to the top
Precision-oriented scenarios

Ideal

Facet 1
- AA
- Delta
- JetBlue

Facet 2
- International
- Domestic

Facet 3
- Weight
- Size
- Quantity

Facet 4
- Business
- Economy
Precision-oriented scenarios

<table>
<thead>
<tr>
<th>Ideal</th>
<th>High “recall”</th>
<th>High “precision”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Facet 1</strong></td>
<td><strong>Facet 1</strong></td>
<td><strong>Facet 1</strong></td>
</tr>
<tr>
<td>❑ AA</td>
<td>❑ Delta</td>
<td>❑ AA</td>
</tr>
<tr>
<td>❑ Delta</td>
<td>❑ Economy</td>
<td>❑ Delta</td>
</tr>
<tr>
<td>❑ JetBlue</td>
<td>❑ AA</td>
<td>❑ JetBlue</td>
</tr>
<tr>
<td><strong>Facet 2</strong></td>
<td><strong>Facet 2</strong></td>
<td><strong>Facet 2</strong></td>
</tr>
<tr>
<td>❑ International</td>
<td>❑ Boarding</td>
<td>❑ Weight</td>
</tr>
<tr>
<td>❑ Domestic</td>
<td>❑ Lounges</td>
<td>❑ Size</td>
</tr>
<tr>
<td><strong>Facet 3</strong></td>
<td><strong>Facet 3</strong></td>
<td><strong>Facet 3</strong></td>
</tr>
<tr>
<td>❑ Weight</td>
<td>❑ International</td>
<td>❑ Business</td>
</tr>
<tr>
<td>❑ Size</td>
<td>❑ Domestic</td>
<td>❑ Lounges</td>
</tr>
<tr>
<td>❑ Quantity</td>
<td>❑ Business</td>
<td></td>
</tr>
<tr>
<td><strong>Facet 4</strong></td>
<td><strong>Facet 4</strong></td>
<td></td>
</tr>
<tr>
<td>❑ Business</td>
<td>❑ Quantity</td>
<td></td>
</tr>
<tr>
<td>❑ Economy</td>
<td>❑ Weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>❑ Size</td>
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</table>
Precision-oriented scenarios

**Ideal**
- **Facet 1**
  - AA
  - Delta
  - JetBlue
- **Facet 2**
  - International
  - Domestic
- **Facet 3**
  - Weight
  - Size
  - Quantity
- **Facet 4**
  - Business
  - Economy

**High “recall”**
- **Facet 1**
  - Delta
  - Economy
  - AA
  - JetBlue
- **Facet 2**
  - Boarding
  - Lounges
- **Facet 3**
  - International
  - Domestic
  - Business
- **Facet 4**
  - Quantity
  - Weight
  - Size

**High “precision”**
- **Facet 1**
  - AA
  - Delta
- **Facet 2**
  - Weight
  - Size
- **Facet 3**
  - Business
  - Economy
  - Lounges

Users would prefer this
Precision-oriented scenarios

Users would prefer this **correctness** of presented facets than the **completeness** of them.
Previous models don’t work so well under precision-oriented scenarios 😞

Low precision

0.4450
Overview of this work

• Improve our previous extraction model under precision-oriented scenarios
  – Likelihood is a bad training objective
  – Directly optimize the performance measure
Overview of this work

- Improve our previous extraction model under precision-oriented scenarios
  - Likelihood is a bad training objective
  - Directly optimize the performance measure

![Histogram showing poor and well-performing queries](image)
Overview of this work

• Improve our previous extraction model under precision-oriented scenarios
  – Likelihood is a bad training objective
  – Directly optimize the performance measure

• Selective query faceting
  – Avoid showing facets for poor performing queries
  – Only trigger faceting for well performing ones
  – Predict extraction performance
Overview of this work

• Improve our previous extraction model under precision-oriented scenarios
  – Likelihood is a bad training objective
  – Directly optimize the performance measure

• Selective query faceting
  – Avoid showing facets for poor preforming queries
  – Only trigger faceting for well performing ones
  – Predict extraction performance

• Improve evaluation measures
  – not included in this talk
Optimize the performance measure
Evaluation measure

- Compare with human created facets

<table>
<thead>
<tr>
<th>Extracted facets</th>
<th>Annotator facets (ground truth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>AA</td>
</tr>
<tr>
<td>Domestic</td>
<td>Delta</td>
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<tr>
<td>Twitter</td>
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- Measures: how to measure similarity
  - Term classification
  - Term clustering
$PRF_{\alpha,\beta}$

- Combine three factors
  - Term Precision
  - Term Recall
  - Pair F1 (term clustering F-measure)

- Using weighted harmonic mean

$$PRF_{\alpha,\beta} = \frac{\alpha^2 + \beta^2 + 1}{\frac{\alpha^2}{TP} + \frac{\beta^2}{TR} + \frac{1}{PF}}$$

Adjust emphasis between factors
\[ PRF_{\alpha,\beta} \]

- Combine three factors
  - Term Precision
  - Term Recall
  - Pair F1 (term clustering F-measure)

- Using weighted harmonic mean

\[
PRF_{\alpha,\beta} = \frac{\alpha^2 + \beta^2 + 1}{\frac{\alpha^2}{TP} + \frac{\beta^2}{TR} + \frac{1}{PF}}
\]

Hold \( \alpha=1 \)
- \( \beta=1 \): equal importance
- \( \beta=\frac{1}{2} \): TR \( \frac{1}{2} \) important as TP, PF
- \( \beta=\frac{1}{3} \): TR \( \frac{1}{3} \) important as TP, PF
  
[ Rijsbergen 1979 ]
Query faceting model

\[ PRF_{\alpha,\beta} \]

Performance measure
Optimize $PRF_{\alpha,\beta}$ directly

Query faceting model

Empirical utility maximization

$$u(\theta) = \sum_{(Y^*,Z^*)} PRF_{\alpha,\beta}(Y^*,Z^*; \theta)$$

Training objective
Optimize $PRF_{\alpha,\beta}$ directly

• But it’s difficult

$$y_i = 1\{P(y_i = 1) > \lambda\}$$

Non-continuous, non-differentiable 😞

• Solution: approximation by its expectation

$$\tilde{y}_i = E[y_i] = P(y_i = 1; \theta)$$

$$\overline{PRF}_{\alpha,\beta} = E[PRF_{\alpha,\beta}] \approx PRF_{\alpha,\beta}(\tilde{Y}, \tilde{Z})$$

Independence assumption
Compare EUM & MLE

EUM: trained by optimize $PRF_{1,0.5}$
MLE: trained by optimize likelihood
Both for QFJ model

†: Significant ($p<0.05$) over MLE baselines
Utility is a better learning objective than likelihood for precision-oriented scenarios.

EUM: trained by optimize $PRF_{1,0.5}$
MLE: trained by optimize likelihood
Both for QFJ model

†: Significant (p<0.05) over MLE baselines
Selective query faceting
Selective query faceting

Only trigger faceting for well performing queries
Predicting Extraction Performance

• Predict $PRF_{\alpha,\beta}$ based on its expectation

Results based on 10-fold cross validation
Predicting Extraction Performance

- Predict $PRF_{\alpha,\beta}$ based on its expectation

Results based on 10-fold cross validation

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<td>$PRF$</td>
<td>0.6112</td>
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Predicting Extraction Performance

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Performance for the selected queries

\[ PRF_{1,1} = 0.5792, \text{ when 20 queries selected} \]

\[ PRF_{1,1} = 0.4720, \text{ when not applying selectively faceting} \]

Gray area indicates standard error with 95% confidence intervals.
Selective query faceting can improve average performance with fair coverage of the search traffic.

\[ PRF_{1,1} = 0.5792, \text{ when 20 queries selected} \]

\[ PRF_{1,1} = 0.4720, \text{ when not applying selectively faceting} \]

Gray area indicates standard error with 95% confidence intervals.
Conclusions

• Precision-oriented scenarios
• Use utility objective instead of likelihood
• Expectation-based approximation is effective
• Selective query faceting can be useful
Future work

- Label query facet

- Rank/select facets and facet terms
  - Critical for mobile search (smaller screen)

- Use query facets for exploratory search
  - Recall-oriented?
  - How to set the task and evaluate?
Thanks

Demo to play with =)

http://broooloo.cs.umass.edu