Enhancing Exploration with a Faceted Browser through Summarization

Grzegorz Drzadzewski

David R. Cheriton School of Computer Science
University of Waterloo
Waterloo, ON, N2L 3G1, Canada
gdrzadze@cs.uwaterloo.ca

Frank Wm. Tompa

David R. Cheriton School of Computer Science
University of Waterloo
Waterloo, ON, N2L 3G1, Canada
fwtompa@cs.uwaterloo.ca

ABSTRACT

An enhanced faceted browsing system has been developed to support users' exploration of large multi-tagged document collections. It provides summary measures of document result sets at each step of navigation through a set of representative terms and a diverse set of documents. These summaries are derived from pre-materialized views that allow for quick calculation of centroids for various result sets. The utility and efficiency of the system is demonstrated on the New York Times Annotated Corpus.

Categories and Subject Descriptors

H.2.4 [Systems]: Textual databases; H.4.3 [Communications Applications]: Information browsers

General Terms

Algorithms, Design

Keywords

document repository, faceted browser, tags, result diversification, bursty terms

1. INTRODUCTION

Faceted browsing and search has emerged as a valuable technique for information access in many e-commerce sites, including Wal-Mart, Home Depot, eBay, and Amazon [15]. Faceted search has also been shown to be effective in helping users navigate document repositories, including the document collection at the University of North Carolina library, and it was preferred by users over traditional search interfaces based on text content alone [10].

With faceted browsing a user can navigate through a document collection by using facets as filters for specifying a document set of interest. Once the result set is narrowed down to a manageable size, the user can examine individual documents. Other than the count of items associated with

each metadata tag for each facet in the result set, faceted browsers do not usually provide any tools to help users understand the contents of the result set. Alternatively, systems such as Scatter/Gather display a link to the medoid document and the top- k most frequently occurring terms [1], which gives a hint at the scope of each sub-collection. If the information provided is not particularly informative, the user must arbitrarily choose individual documents to examine in an attempt to understand what is in the isolated sub-collection.

When navigating through many document sets, however, it is too time consuming to examine many documents from each set to determine whether the set as a whole or some subset may be of interest. As a user aid, document sets may be summarized to provide a quick overview of their contents. Common summaries for sets of documents include a representative set of terms [7, 8], a ranked list of representative documents [1, 2, 5], and a natural language abstract [9]. Each of these approaches relies on being able to compute the centroid for any given document set.

We have developed an enhanced faceted browser interface that, in addition to letting a user perform traditional faceted browsing and searching, provides a user with summary information about the resulting document set. In our implementation, the summary includes a diverse set of representative documents and a well-chosen set of representative terms. In addition, the information scent [6] is enhanced by providing a set of representative terms for each of the important *sub-collections* of the result set (cf. multi-menus [11]). With these summary measures in place, a user is able to quickly grasp the topics covered by large result sets. This additional summary information can be especially useful in situations when the documents are not ordered in a favourable way (such as when using PubMed, where result sets are ordered by date rather than by relevance to the query).

We demonstrate the system on the New York Times (NYT) annotated corpus [12], which consists of 1.5 million tagged documents. The assigned tags are treated as facet values over which the user can search and browse.

2. BASIC MEASURES OF INTEREST

2.1 Set Centroid

Following standard practice in information retrieval, we model a document as a *bag of terms* represented by a document term vector (DTV), which is a vector of values where each entry corresponds to a term together with the term's (normalized) frequency in that document. A set of DTVs

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can be aggregated together to obtain a *set centroid* for the corresponding documents, which can be used by set summarization procedures. A set centroid C is represented by a vector of term frequencies equal to the mean of all the DTVs for documents that belong to that set.

2.2 Representative Terms

Given a document set of interest S_c and a superset $S_p \supseteq S_c$ (its context), the *burstiness* of a term w is measured using $B_+(w, C_{S_c}, C_{S_p})$ as defined in Equation 1, where C_{S_c} is the centroid of set S_c and C_{S_p} is the centroid of its context S_p :

$$B_+(w, C_{S_c}, C_{S_p}) = \frac{C_{S_c}[w].freq}{C_{S_p}[w].freq^{0.95}} \quad (1)$$

A term is considered *bursty* if it has a sufficiently higher frequency of occurrence in set S_c than its frequency of occurrence in the context set S_p : $B_+(w, C_{S_c}, C_{S_p}) > t$, where t is pre-defined threshold (set to 1 in our system). The top k or fewer (if fewer than k terms are above the threshold) bursty terms found in C_{S_c} constitute the set of representative terms $\mathbb{B}_k(S_c, S_p)$ for S_c relative to S_p .

Since the absence of terms may often be as informative as their presence, we also want to show terms that occur significantly less in the set than in its superset. Therefore, we define negative burstiness, denoted $B_-(w, C_{S_c}, C_{S_p})$, as defined in Equation 2.

$$B_-(w, C_{S_c}, C_{S_p}) = \frac{C_{S_p}[w].freq}{C_{S_c}[w].freq^{0.95}} \quad (2)$$

The top k or fewer terms in C_{S_c} with $B_-(w, C_{S_c}, C_{S_p}) > t$ are then displayed as part of the summary, representing a set of rare terms (denoted $\mathbb{B}_k^-(S_c, S_p)$) for S_c relative to S_p .

As an example, Table 1 shows the set of positive and negative bursty terms (labelled “representative terms” and “rarely occurring terms,” respectively) for the document set returned in response to the query “Music,” along with the bursty terms associated with its two largest subsets: “Music AND Recordings (Audio)” and “Music AND Opera.” The representative terms for the query “Music” are derived using $\mathbb{B}_{20}(S_{Music}, S_G)$, where S_G corresponds to all documents in the corpus, and those for “Music AND Recordings (Audio)” and “Music AND Opera” are defined with respect to “Music” using $\mathbb{B}_{20}(S_{Music \wedge Recordings(Audio)}, S_{Music})$ for the former and $\mathbb{B}_{20}(S_{Music \wedge Opera}, S_{Music})$ for the latter; the rarely occurring terms use the corresponding negated formulae.

3. REPRESENTATIVE DOCUMENTS

3.1 Approaches to Diversification

There is a large body of research on search result diversification [14]. However, that work deals with diversification of results to ambiguous queries, for which different results are optimal depending on the interpretation of the query. That body of work is not directly applicable to our scenario since we do not deal with queries over text, but rather with navigation over tags. Because documents are assigned single instances of tags (we are not considering folksonomies, where the same tag can be assigned to a document by many users), documents matching a query over tags cannot be ordered based on the tag frequency in a similar fashion as term frequency is used to rank documents in a standard text search. Instead, in situations where documents are equal members

Table 1: Summary generated for the query “Music” in the NYT.

Query	Music
Doc. Count	57,192
Rep. Doc.	<i>Anniversaries Fill the Halls With Melody</i>
Repres. Terms	sonata*,orchestra*,album*,concerto*,beethoven*,guitar*,brahm*,quartet*,philharmon*,melodi*,schubert*,mezzo*,bassist*,melod*,saxophonist*,pianist*,symphoni*,saxophon*,bariton*,cello*
Rarely Occurring Terms	report*
Subquery	Music AND Recordings (Audio)
Subset Count	7,728
Rep. Doc.	<i>A Once Proud Industry Fends Off Extinction</i>
Repres. Terms	cassett*,cd*,reissu*,emi*,disk*,grammophon*,bmg*,soni*,label*,disc*,rca*,record*,album*,analyst*,nonesuch*,releas*,chart*,parel*,billion*,soundtrack*
Rarely Occurring Terms	tulli*,pm*,averi*,intermiss*,tomorrow*,ticket*,tonight*,fisher*,carnegi*,saturdai*,hall*,alic*,costum*,metropolitan*,sundai*recit*,auditorium*,lincoln*,festiv*,concert*
Subquery	Music AND Opera
Subset Count	6,408
Rep. Doc.	<i>Rossini, Hold the Pasta Sauce</i>
Repres. Terms	opera*,libretto*,figaro*,puccini*,donizetti*,verdi*,metropolitan*,coloratura*,costum*,wagner*,operat*,luciano*,aria*,rossini*,und*stage*,scene*,tenor*,la*,dramat*
Rarely Occurring Terms	saxophonist*,bassist*,guitarist*,rapper*,drummer*,guitar*,album*,songwrit*,band*,sonata*,jam*,rap*,punk*,drum*,jazz*improvis*,funk*,hop*,saxophon*,rock*
⋮	⋮

of a set, representative documents are picked based on the centroid of the set, and the set is represented through a medoid [1] or through a set of documents that provide coverage of important concept terms stored in the centroid [2].

Using multiple documents to cover all the important concept terms found in the centroid of a set may be appropriate for representing a flat set, but in a collection with multi-tagged documents, as is the case with NYT, most sets can be partitioned into coherent subsets. For example, a set of documents defined by the “Music” tag can be partitioned into subsets, such as “Music AND Opera,” derived by intersecting multiple dominant tags found in the set. These subsets impose a hierarchy over the set, which can be used for choosing a diverse representative set of documents, similarly to what was proposed by Vee et al. [16]. A set generated through this approach has documents that represent concepts found in many centroids of various subsets in the set of interest, and so will have a richer diversity than is possible with the coverage approach whose documents are optimized to cover a single centroid. This approach parallels the use of query reformulations to provide diverse sets of results for web searches [13].

Table 2: Analysis of documents returned for a query on bursty terms with respect to the corresponding tags (where only result sets of size greater than 100 are considered)

Query Type	Instance Count	Mean Precision at 100	Mean Rank of Top Relevant Doc.
t_x	1,015	62.4 $\sigma=23.0$	1.44 $\sigma=1.42$
$t_x \wedge t_y$	5,179	70.7 $\sigma=20.6$	1.25 $\sigma=0.98$

Instead of calculating the medoid directly from the cosine distance of each document from the centroid, we take advantage of the infrastructure provided by a standard information retrieval system such as Lucene. Given a query, Lucene’s ranking function ranks a document highly if the terms specified in a query appear frequently in the document and the document contains many of the terms specified in the query. This aligns well with the properties used for evaluating whether or not a document is a good representative of a set (i.e., it provides good coverage of the important concept terms of the centroid and those terms occur frequently in the document). As a result, the highest ranked document to a query consisting of the bursty terms of a set centroid makes a good representative document for the corresponding set. Since bursty terms are all relatively rare in the corpus, the ranking function will not likely have a strong bias towards documents that represent only some of the query terms.

We have examined the quality of this mapping between tags and the top 20 bursty terms describing the corresponding centroids (Table 2) to determine whether documents that contain the bursty terms tend to be in the expected subset (having the corresponding tag). The mapping was evaluated over all sets that have at least 100 documents and are defined by a single tag or by a conjunction of two tags. The top 20 bursty terms representing each of those sets were used to formulate queries. For each of those queries, a large proportion of the top 100 documents in the ranked lists of results are annotated with the corresponding tag or tags. Thus, there is a high correlation between the tags and the content text. In addition, the highest ranked result to the query on the bursty terms predominantly comes from the same set as the bursty terms. The existence of the required tags on many of the top 100 documents returned by a bursty terms query confirms the influence of the identified bursty terms in defining a document set. Furthermore, since many relevant documents are found in the top 100 results, various IR optimization techniques that take advantage of early termination can be used without fear of missing a representative document.

3.2 Finding Representative Documents

Given a query Q defining a set of documents S_Q , let $t_1, t_2, \dots, t_n$ be a ranked sequence of tags for which the rank of tag t_i is based on $|S_{Q \wedge t_i}|$ and the dissimilarity of $S_{Q \wedge t_i}$ with respect to both S_Q and other subsets $S_{Q \wedge t_j}$ where $j < i$. (Details of the tag ranking algorithm are given in the full description of the system [3].) The $N + 1$ diverse representative documents for S_Q , denoted by $\mathbb{D}_Q(N, k)$, are defined

using Equation 4.

$$D_Q(i, k) = \begin{cases} R(\mathbb{B}_k(S_Q, S_G)) & \text{if } i = 0 \\ R(\mathbb{B}_k(S_{Q \wedge t_i}, S_Q)) & \text{if } i > 0 \end{cases} \quad (3)$$

$$\mathbb{D}_Q(N, k) = \bigcup_{i=0}^N D_Q(i, k) \quad (4)$$

where S_G corresponds to all documents in the corpus and $R(x)$ returns the document in S_Q that is top ranked when posing the text query using the terms in the set x .

For example, $D_{Music}(0, 20)$ is found by taking the top 20 positive bursty terms, which include stemmed words such as *sonata*, *orchestra*, *album*, *concerto*, and *beethoven*, and issuing a text query with those terms. The highest ranked document in set S_{Music} is chosen as a representative document, which happens to be the document with title *Anniversaries Fill the Halls With Melody* as shown in Table 1. $D_{Music}(1, 20)$ is found using the bursty terms in the largest subset, “Music\Recordings (Audio),” and $D_{Music}(2, 20)$ uses the subset “Music\Opera.” For our example, $\mathbb{D}_{Music}(2, 20)$ is displayed in Table 1, and these three documents together form a diverse representative document set for S_{Music} .

4. SYSTEM ARCHITECTURE

The architecture of the faceted browsing system is shown in Figure 1. The system relies on the Partial Materialization Module, described by Drzadzewski and Tompa [4], which is central to efficient system performance. The module is designed to ensure fast access to requested centroids of document sets defined through Boolean operations over tags, while consuming minimal storage. Fast access to the centroid measure for document sets makes it feasible to produce the proposed summary measures for many sets within a short amount of time, so that a user can interactively explore large document collections. For example, with the help of the Partial Materialization Module, a centroid for a document set consisting of 142,000 documents can be obtained in under two seconds, whereas it would take 120 seconds to calculate the same centroid by aggregating individual documents.

When a user specifies a query over tags, the system produces a summary for the resulting documents by first accessing the Tag-Tag Index and a Tag-Document Index found in the Partial Materialization Module to produce a ranked sequence of N tags, such that each chosen tag produces a large subset that is dissimilar from both the document set of interest and subsets produced by other selected tags. These tags are then individually combined with the original query as a conjunction in order to produce N sub-queries. (For the query “Music,” sub-queries such as “Music AND Recordings (Audio)” and “Music AND Opera” are generated.) The original query along with the N sub-queries are then fed into the Partial Materialization Module, which produces a centroid for each of the queries along with the centroid for the whole corpus.

The resulting centroids are compared against each other to derive both positive and negative bursty terms (Eqns. 1 and 2) for the result set and principal subsets. The positive bursty terms are then used to form multiple text queries (a separate query for each set of bursty terms) (Eqns. 3 and 4). The highest ranked documents returned from each search

Figure 1: System for supporting faceted browsing

along with the corresponding bursty terms are returned to the user to produce the summary of the resulting set similar to Table 1.

The user interface is developed as a web app, and Lucene is used for indexing the documents and for supporting text queries through the standard ranking function. Additional information about the system is provided in the full system description [3] and on our website¹.

5. CONCLUSIONS

Whereas a standard faceted browser in response to a user’s query on a tag (e.g., “Music”) would produce a list of all documents that have that tag (which happen to be 57,192 documents) as well as a list of facets and the number of documents associated with each facet (“Recordings (Audio)” with 7,728 documents, and “Opera” with 6,408 documents), our system also provides a set of diverse representative documents that come from the various subsets (defined by queries “Music AND Recordings (Audio)”, and “Music AND Opera”) as well as representative terms for the result set and each principal subset. This information provides a useful summary and an information scent so users can make informed decisions as to which subset(s) they may want to explore further.

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¹<http://www.db.uwaterloo.ca/TagBrowser2015/>

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