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A Preliminary User's Guide for Rhapsode – a Lightweight Document Search Prototype, v0.3.2-BETA

October, 2017

DRAFT

Version 0.3.2-BETA

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Executive Summary

Rhapsode is a free-text search prototype that will enable users to define requirements for their search needs. These requirements can be used in selecting a commercial tool or in guiding developers. Rhapsode is designed to work on a desktop with a single user at a time. Rhapsode is not designed to solve enterprise wide information retrieval tasks.

This users’ guide has not yet been fully updated for Rhapsode 0.3.2-BETA. I offer it as a

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1. Introduction

1.1 About MITRE

The MITRE Corporation is a not-for-profit organization chartered to work in the public interest. As a national resource, we apply our expertise in systems engineering, information technology, operational concepts, and enterprise modernization to address our sponsors' critical needs.[1]

1.2 Purpose and Scope of Rhapsode

Rhapsode is a free-text search prototype. The goal of the prototype is to help users define requirements for their search needs. These requirements can then be used in selecting a commercial tool or in guiding developers. With a few exceptions, Rhapsode is a lightweight integration of open source software libraries. While these libraries offer a tremendous amount of flexibility in indexing and searching, we have selected the most basic options for this prototype. The sponsor documents are primarily in English, and they are mostly comprised of the following formats: Microsoft Office, PDF and Ascii or UTF-8 html/text files. Rhapsode is designed to work on a desktop with a single user at a time. Rhapsode is not intended to solve enterprise-wide search tasks.

We have tried to make this user's guide as accessible as possible. There is a quick-start guide, and we have general/basic sections as well as advanced sections and topics. We try to label each as such so that the reader can skip the advanced sections and options when getting acquainted with Rhapsode.

In ancient Greece, a *rhapsode* was an epic poet who wove together syntactic and narrative elements from the long tradition of oral poetry in order to create a new narrative. Knowledge workers today often weave together disparate pieces of information to gain new insight into their area of study.

1.3 System Requirements

Rhapsode is written in Java, and was developed on a Windows 10 operating system. Rhapsode requires at least Java 8. We have not tested Rhapsode on Windows XP or Linux operating systems. We have only tested the Rhapsode indexer and searcher on a 64-bit Windows 10 operating system with Internet Explorer 11 and Google Chrome. Rhapsode now includes a 64-bit Java Runtime Environment (JRE) under "resources/jres". Version 0.30 of Rhapsode includes Java version 1.8.0_92-b14.

From a port security standpoint, the Rhapsode search server communicates only through 127.0.0.1 (`localhost`) on port 8092. As a security feature, we have compiled these settings into the application, and they are not modifiable without recompiling the source code.

[1] Source: http://www.mitre.org/about/

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1.4 Changes

Version 0.3.2-BETA (October, 2017)
First release

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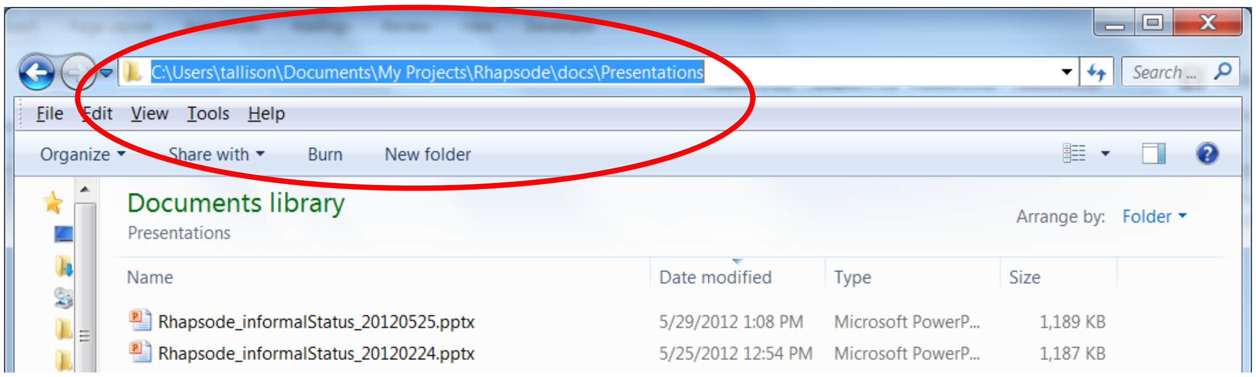
2. Quick Start Guide

The first step is to unzip the zip file and maintain the directory hierarchies. The code needs to be executed in a mapped directory, not a directory identified by a network path. If you are working in Windows 10, click on the file location, and if it starts with a letter followed by a colon, as in Figure 2-1, the code will run. However, if the path starts with two backslashes, that directory points to a network location and is a UNC path. If this is the case, check your documentation for how to map a network drive.

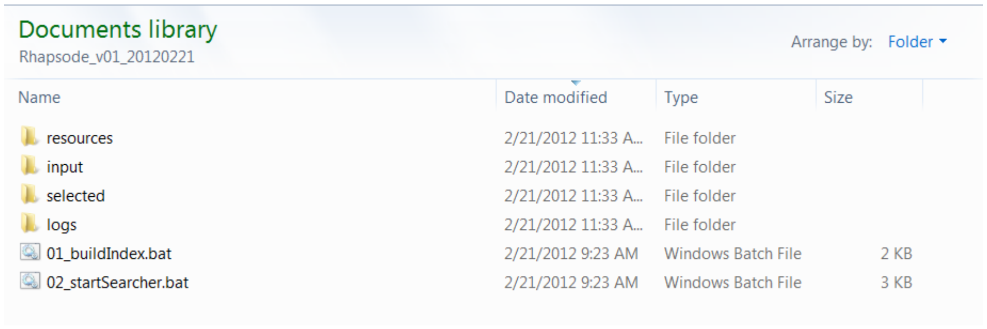

C:\Users\tallison\Documents\My Projects\Rhapsode\docs\Presentations

File Edit View Tools Help
Organize Share with Burn New folder
Search ...
Documents library
Presentations
Arrange by: Folder

Name	Date modified	Type	Size
Rhapsode_informalStatus_20120525.pptx	5/29/2012 1:08 PM	Microsoft PowerP...	1,189 KB
Rhapsode_informalStatus_20120224.pptx	5/25/2012 12:54 PM	Microsoft PowerP...	1,187 KB

Figure 2-1: Example of a Directory Path that Starts with a Directory Letter

After completing the unzipping process, you will see folders and batch files as shown in Figure 2-2.



Name	Date modified	Type	Size
resources	2/21/2012 11:33 A...	File folder	
input	2/21/2012 11:33 A...	File folder	
selected	2/21/2012 11:33 A...	File folder	
logs	2/21/2012 11:33 A...	File folder	
01_buildIndex.bat	2/21/2012 9:23 AM	Windows Batch File	2 KB
02_startSearcher.bat	2/21/2012 9:23 AM	Windows Batch File	3 KB

Figure 2-2: Main Directory for Rhapsode

The first step is to build an index. Place your documents in the “input” directory, and double-click “01_buildIndex.bat”. A command window will pop up and show some status messages. When the index is completed, the command window will output the results and wait for the user to press the return key.

Once the index has been built and the user has closed the indexer command window, the second step is to launch the Rhapsode search server. Double-click “02_startSearcher.bat”, and a command window will open. At the same time, your default browser *should* automatically open

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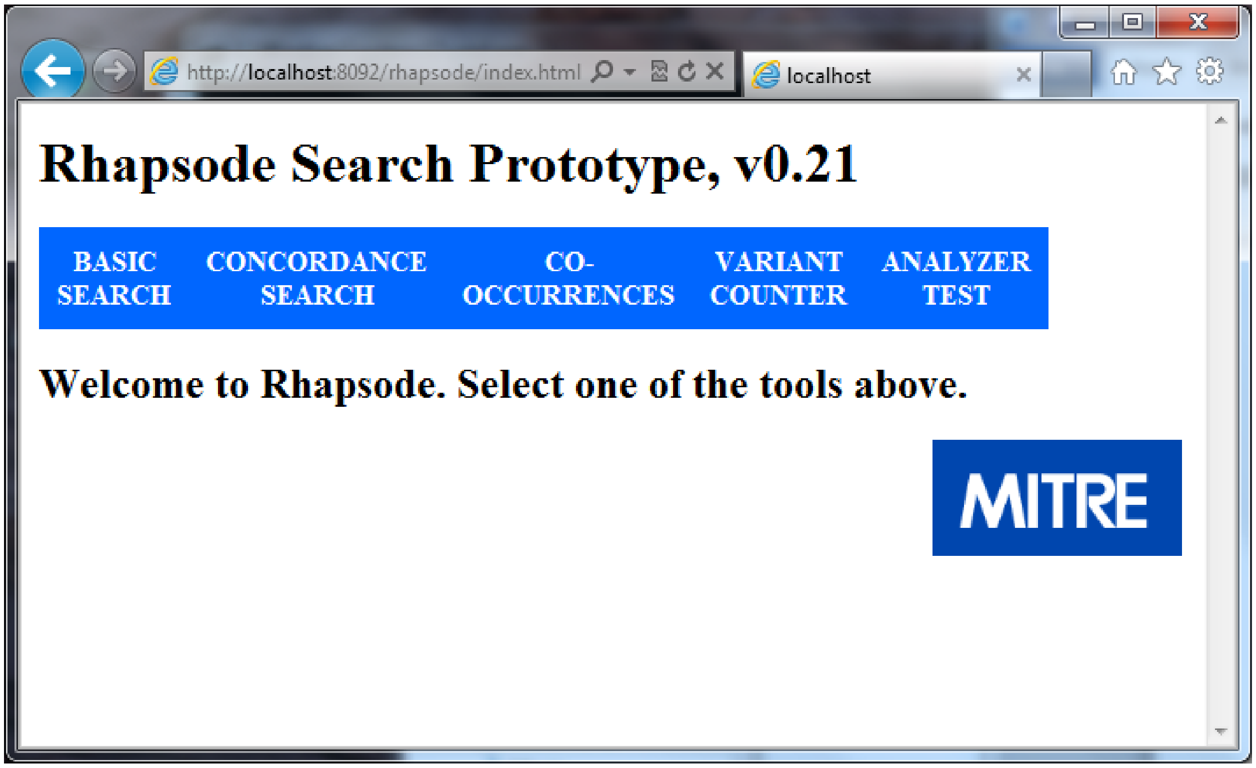
to the correct address: http://localhost:8092/rhapsode/index.html. **Leave the command window open.**

Once the server has started, if the browser window hasn't opened automatically already, open a web browser and navigate to http://localhost:8092/rhapsode/index.html. You should see something similar to Figure 2-3.



Welcome to Rhapsode. Select one of the tools above.

Figure 2-3: Main Screen for Rhapsode

The options:

Basic Search. This allows the user to see a few relevant snippets for each document; this format is similar to what most web search engines offer.

Concordance Search. This search returns every mention of the search term(s). The user can sort the results in various ways.

Co-Occurrences. This performs a concordance search in the background and counts the number of terms that co-occur with your search term.

Variant Counter. This allows the user to see how wild card and fuzzy queries match terms in the index. For example, if you type "`f?x`," and your corpus contains both "`fax`" and "`fox`", these words will be displayed along with their document frequencies. This also allows the user to see how normalization is working.

Analyzer Test. Behind the scenes, an open source component breaks document text and queries into words. This process is called tokenization. It is often helpful to see how this component is carrying out that step. For example, if you enter "http://www.cnn.com", you will

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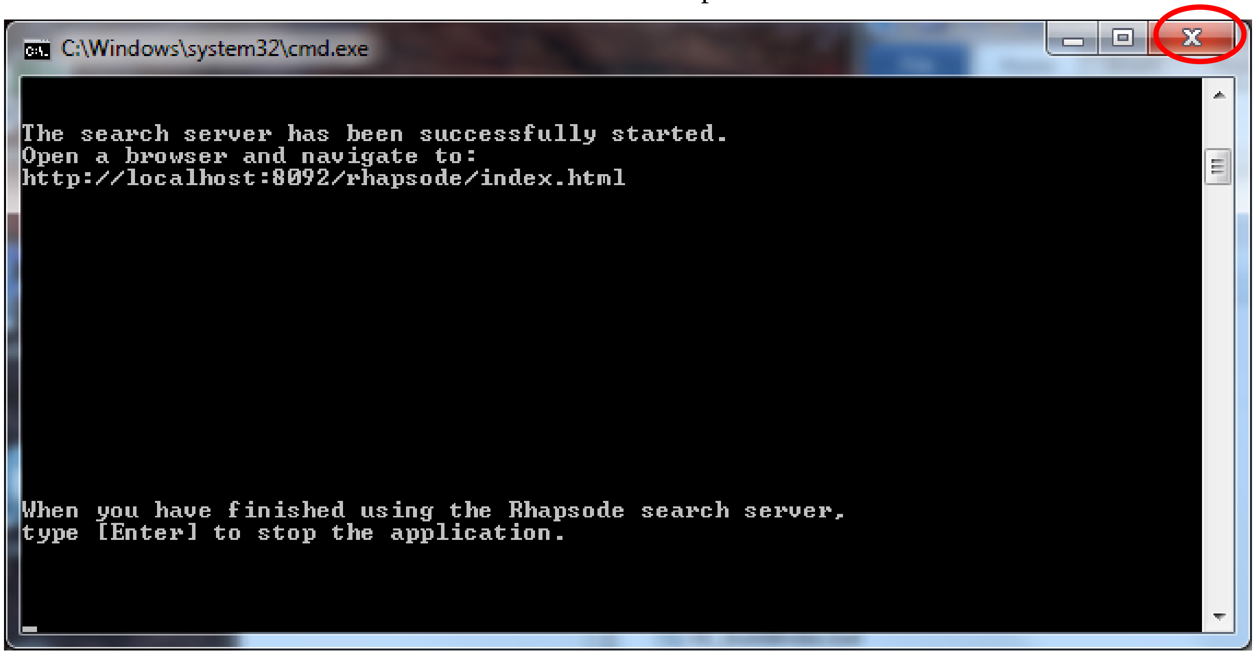
see that the current analyzer is breaking that string into two tokens. If you enter “the quick brown fox,” you will see that the current analyzer is deleting common words (“the” in this case).

Select one of the options and explore.

When you have finished working with the search application, either type the [Enter] key in the command window or click on the red *X* at the top of the command window.



```
The search server has been successfully started.
Open a browser and navigate to:
http://localhost:8092/rhapsode/index.html




When you have finished using the Rhapsode search server,
type [Enter] to stop the application.
```

Figure 2-4: Server Command Window

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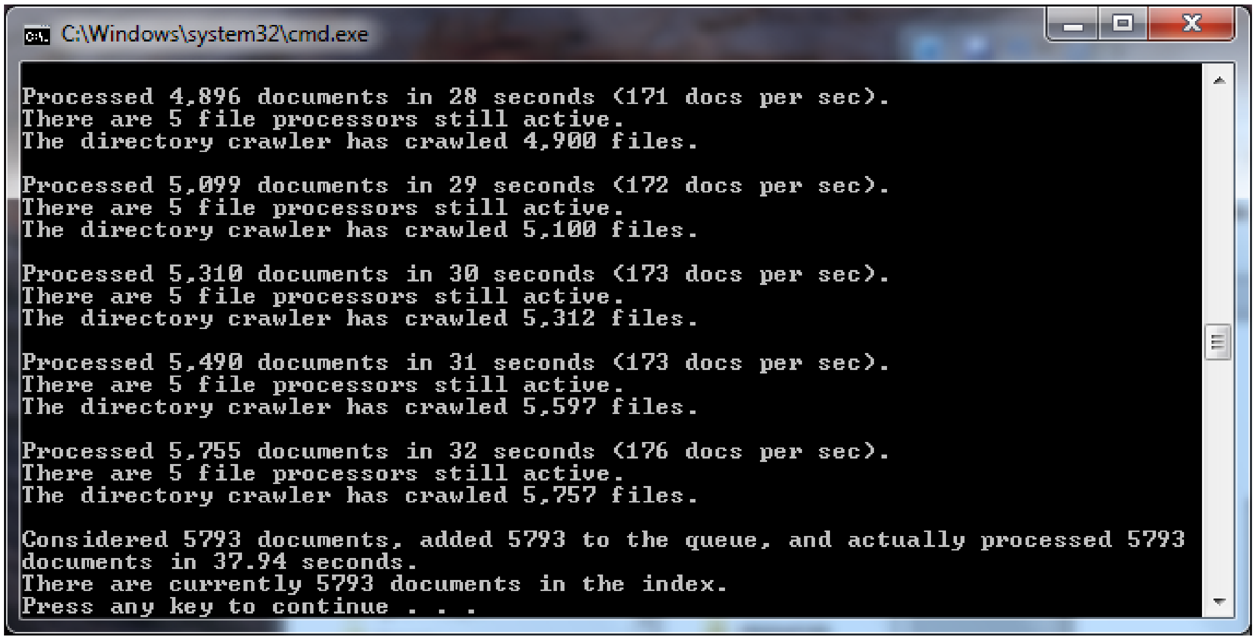
3. Building an Index

3.1 Basic: Indexing a Directory of Files

There are several parameters that can be set before building an index. These parameters include such items as:

1) the directory locations of the index directory and the input directory
2) whether or not to append to or overwrite the current index
3) the maximum file of a size to be processed
4) the maximum number of words to be indexed per document
5) the number of threads to use during indexing

To run the indexer, **make sure that the search server is turned off.** Place your files in the "input" folder and double-click the "01_buildIndex.bat" file. A command window will open and report on its status (see Figure 3-1). When the indexer completes, the command window will report that the indexing has completed, and the user then closes the command window, either by pressing the "Enter" key in the command window or by clicking on the close icon in the top right.



```
Processed 4,896 documents in 28 seconds (171 docs per sec).
There are 5 file processors still active.
The directory crawler has crawled 4,900 files.

Processed 5,099 documents in 29 seconds (172 docs per sec).
There are 5 file processors still active.
The directory crawler has crawled 5,100 files.

Processed 5,310 documents in 30 seconds (173 docs per sec).
There are 5 file processors still active.
The directory crawler has crawled 5,312 files.

Processed 5,490 documents in 31 seconds (173 docs per sec).
There are 5 file processors still active.
The directory crawler has crawled 5,597 files.

Processed 5,755 documents in 32 seconds (176 docs per sec).
There are 5 file processors still active.
The directory crawler has crawled 5,757 files.

Considered 5793 documents, added 5793 to the queue, and actually processed 5793
documents in 37.94 seconds.
There are currently 5793 documents in the index.
Press any key to continue . . .
```

Figure 3-1: Indexer Command Window

The indexer reports exceptions and warnings in a file called "indexer.log" which is located in the "logs" directory at the main directory level. **Do not start the searcher until the indexer has completed and the command window has been closed.**

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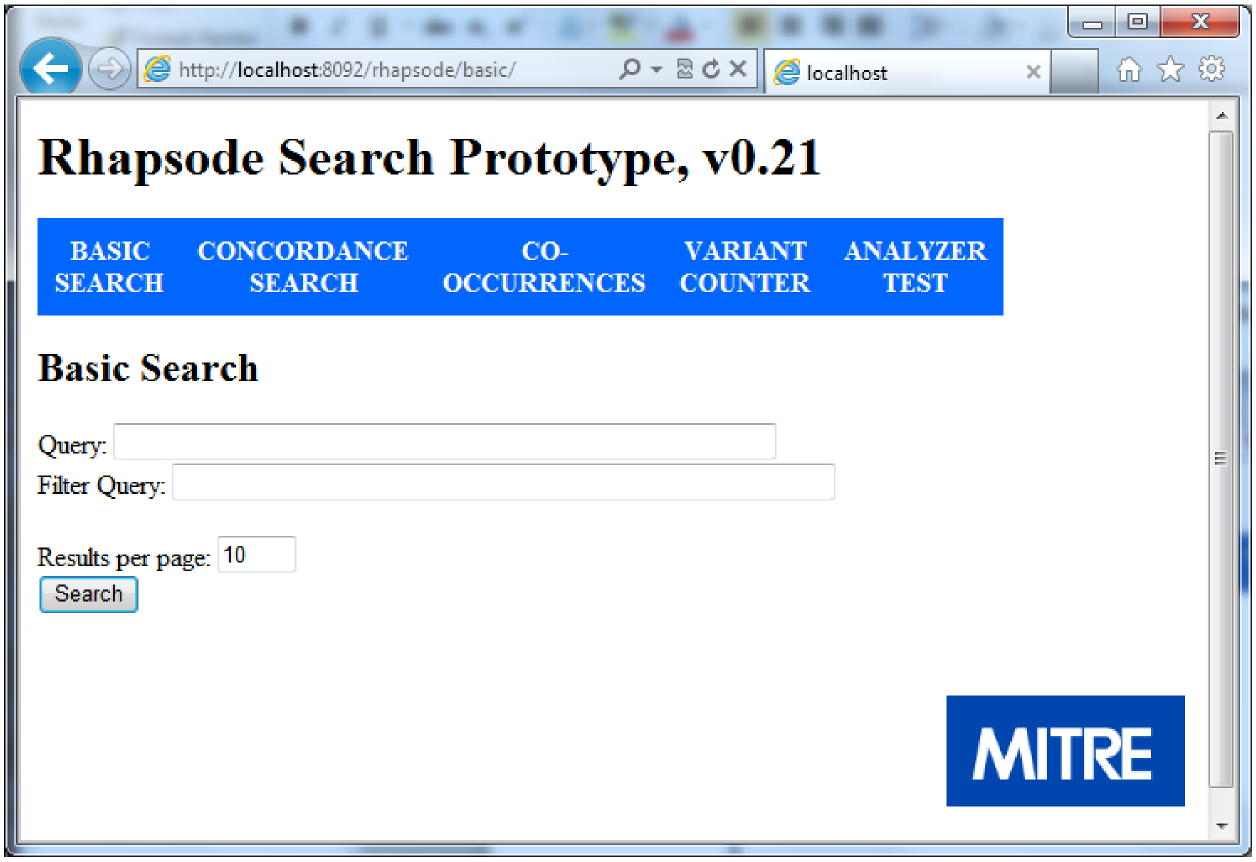
4. Searching an Index

4.1 Basic Search

The goal of basic search is to allow users to identify documents that contain terms of interest. The interface has only three main options: the query, the filter query and the number of results to display per page (see Figure 4-1).



Rhapsode Search Prototype, v0.21

Basic Search

Query:

Filter Query:

Results per page: 10

Figure 4-1: Basic Search First Window

Once we make a query, we see results as shown in Figure 4-2.

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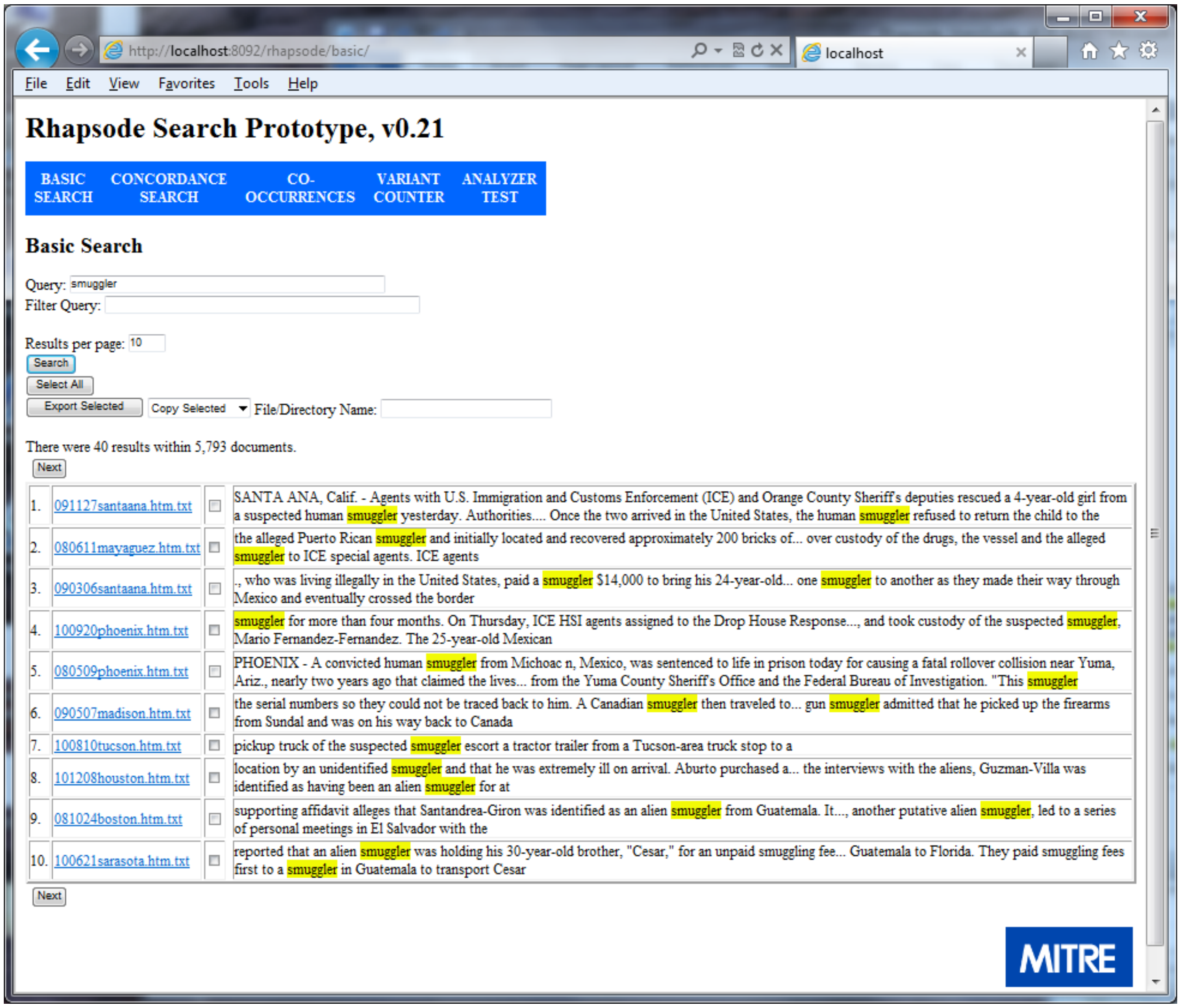
http://localhost:8092/rhapsode/basic/
localhost
File Edit View Favorites Tools Help

Rhapsode Search Prototype, v0.21

Basic Search

Query: smuggler
Filter Query:

Results per page: 10

File/Directory Name:

There were 40 results within 5,793 documents.

1.	091127santaana.htm.txt	☐	SANTA ANA, Calif. - Agents with U.S. Immigration and Customs Enforcement (ICE) and Orange County Sheriff's deputies rescued a 4-year-old girl from a suspected human smuggler yesterday. Authorities.... Once the two arrived in the United States, the human smuggler refused to return the child to the
2.	080611mayaguez.htm.txt	☐	the alleged Puerto Rican smuggler and initially located and recovered approximately 200 bricks of... over custody of the drugs, the vessel and the alleged smuggler to ICE special agents. ICE agents
3.	090306santaana.htm.txt	☐	., who was living illegally in the United States, paid a smuggler $14,000 to bring his 24-year-old... one smuggler to another as they made their way through Mexico and eventually crossed the border
4.	100920phoenix.htm.txt	☐	smuggler for more than four months. On Thursday, ICE HSI agents assigned to the Drop House Response..., and took custody of the suspected smuggler, Mario Fernandez-Fernandez. The 25-year-old Mexican
5.	080509phoenix.htm.txt	☐	PHOENIX - A convicted human smuggler from Michoac n, Mexico, was sentenced to life in prison today for causing a fatal rollover collision near Yuma, Ariz., nearly two years ago that claimed the lives... from the Yuma County Sheriff's Office and the Federal Bureau of Investigation. "This smuggler
6.	090507madison.htm.txt	☐	the serial numbers so they could not be traced back to him. A Canadian smuggler then traveled to... gun smuggler admitted that he picked up the firearms from Sundal and was on his way back to Canada
7.	100810tucson.htm.txt	☐	pickup truck of the suspected smuggler escort a tractor trailer from a Tucson-area truck stop to a
8.	101208houston.htm.txt	☐	location by an unidentified smuggler and that he was extremely ill on arrival. Aburto purchased a... the interviews with the aliens, Guzman-Villa was identified as having been an alien smuggler for at
9.	081024boston.htm.txt	☐	supporting affidavit alleges that Santandrea-Giron was identified as an alien smuggler from Guatemala. It..., another putative alien smuggler, led to a series of personal meetings in El Salvador with the
10.	100621sarasota.htm.txt	☐	reported that an alien smuggler was holding his 30-year-old brother, "Cesar," for an unpaid smuggling fee... Guatemala to Florida. They paid smuggling fees first to a smuggler in Guatemala to transport Cesar

Figure 4-2: Basic Search Results

The user can iterate through the results by hitting the "Next" button. The user may choose to view the document by clicking on the link to the left. The user is able to adjust the results per page, and the user may submit a new query.

4.2 Concordance Search

4.2.1 Concordance Search: Basic

While basic search allows a user to identify documents that contain a query term, concordance search allows the user to see every time a given term appears in the document set. We show the first screen in Figure 4-3.

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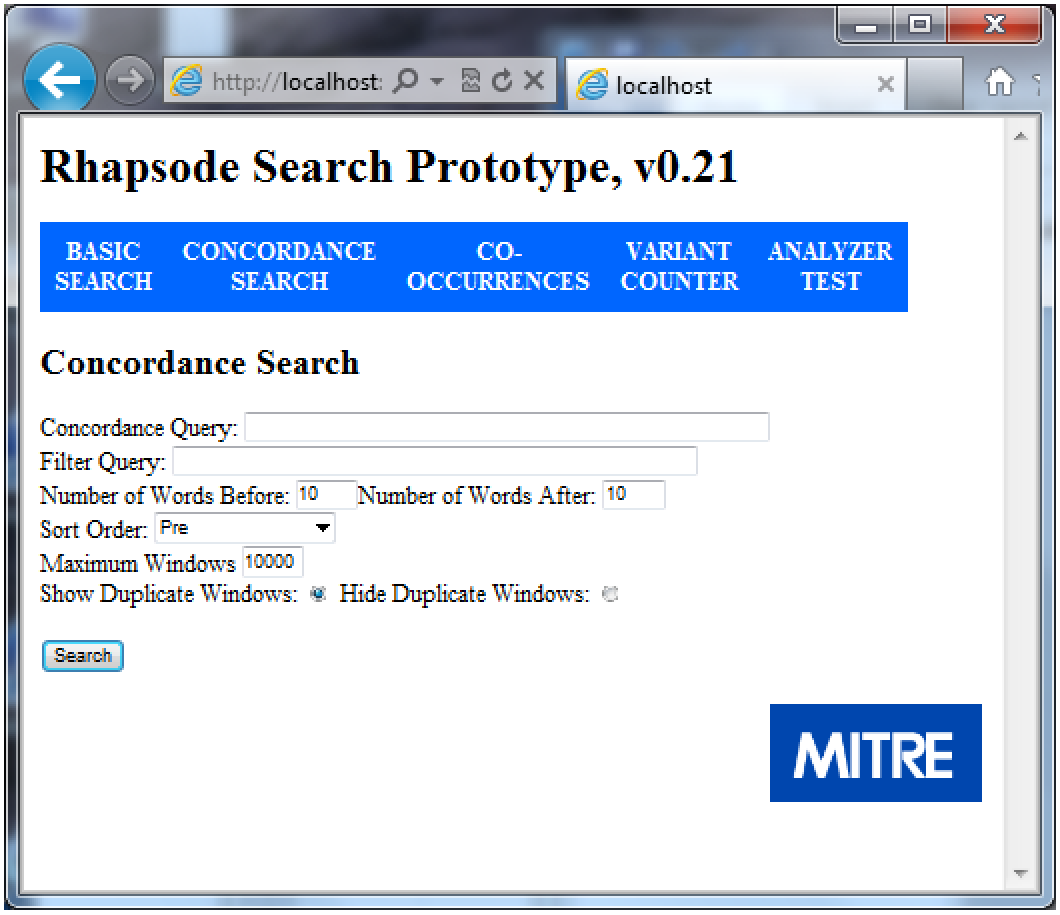

Rhapsode Search Prototype, v0.21

Concordance Search

Concordance Query:
Filter Query:
Number of Words Before: 10 Number of Words After: 10
Sort Order: Pre
Maximum Windows 10000
Show Duplicate Windows: ● Hide Duplicate Windows: ○

Figure 4-3: First Screen for Concordance Search

For general usage, the user enters a query term in the "Concordance Query" window and then clicks the "Search" button. The results are shown in Figure 4-4.

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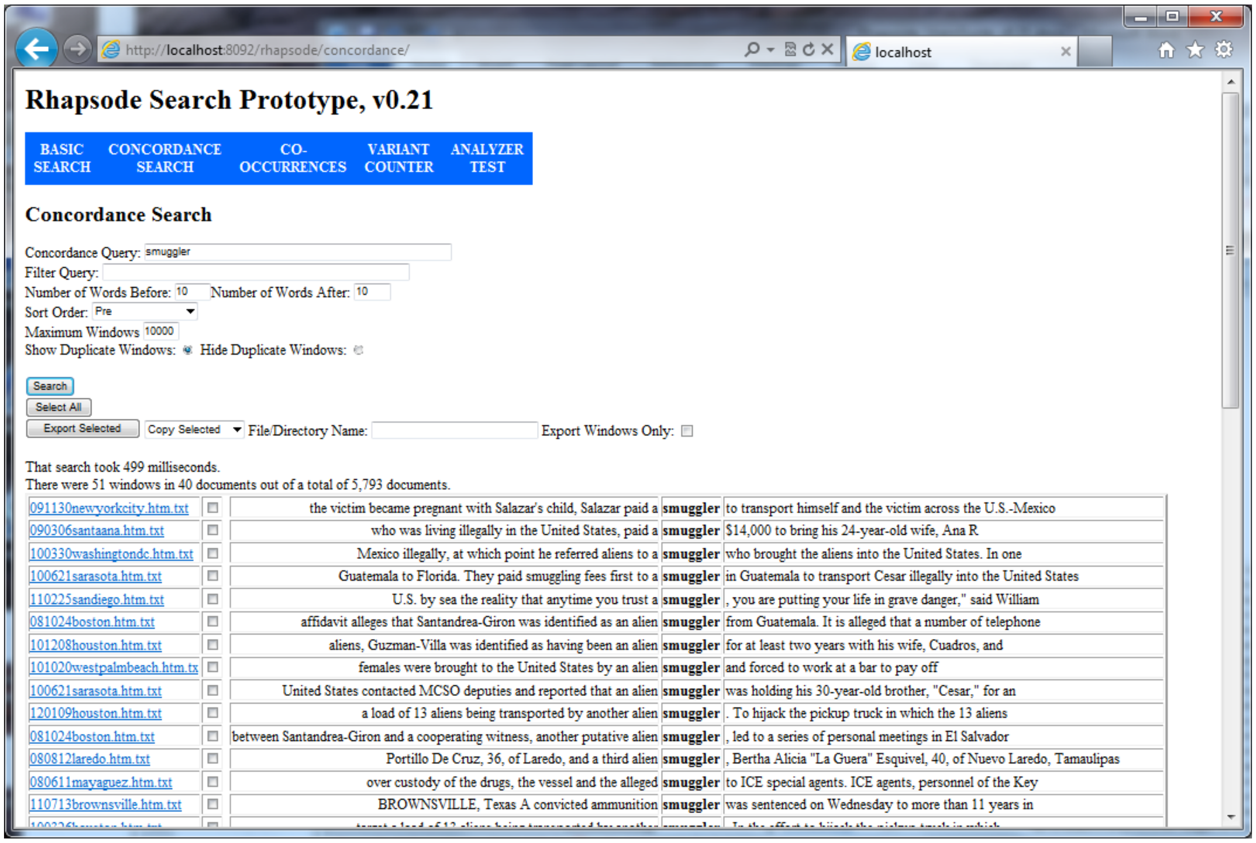
http://localhost:8092/rhapsode/concordance/

Rhapsode Search Prototype, v0.21

Concordance Search

Concordance Query: smuggler
Filter Query:
Number of Words Before: 10 Number of Words After: 10
Sort Order: Pre
Maximum Windows 10000
Show Duplicate Windows: ● Hide Duplicate Windows: ○

That search took 499 milliseconds.
There were 51 windows in 40 documents out of a total of 5,793 documents.

091130newyorkcity.htm.txt	☐	the victim became pregnant with Salazar's child, Salazar paid a	**smuggler**	to transport himself and the victim across the U.S.-Mexico
090306santaana.htm.txt	☐	who was living illegally in the United States, paid a	**smuggler**	$14,000 to bring his 24-year-old wife, Ana R
100330washingtondc.htm.txt	☐	Mexico illegally, at which point he referred aliens to a	**smuggler**	who brought the aliens into the United States. In one
100621sarasota.htm.txt	☐	Guatemala to Florida. They paid smuggling fees first to a	**smuggler**	in Guatemala to transport Cesar illegally into the United States
110225sandiego.htm.txt	☐	U.S. by sea the reality that anytime you trust a	**smuggler**	, you are putting your life in grave danger," said William
081024boston.htm.txt	☐	affidavit alleges that Santandrea-Giron was identified as an alien	**smuggler**	from Guatemala. It is alleged that a number of telephone
101208houston.htm.txt	☐	aliens, Guzman-Villa was identified as having been an alien	**smuggler**	for at least two years with his wife, Cuadros, and
101020westpalmbeach.htm.tx	☐	females were brought to the United States by an alien	**smuggler**	and forced to work at a bar to pay off
100621sarasota.htm.txt	☐	United States contacted MCSO deputies and reported that an alien	**smuggler**	was holding his 30-year-old brother, "Cesar," for an
120109houston.htm.txt	☐	a load of 13 aliens being transported by another alien	**smuggler**	. To hijack the pickup truck in which the 13 aliens
081024boston.htm.txt	☐	between Santandrea-Giron and a cooperating witness, another putative alien	**smuggler**	, led to a series of personal meetings in El Salvador
080812laredo.htm.txt	☐	Portillo De Cruz, 36, of Laredo, and a third alien	**smuggler**	, Bertha Alicia "La Guera" Esquivel, 40, of Nuevo Laredo, Tamaulipas
080611mayaguez.htm.txt	☐	over custody of the drugs, the vessel and the alleged	**smuggler**	to ICE special agents. ICE agents, personnel of the Key
110713brownsville.htm.txt	☐	BROWNSVILLE, Texas A convicted ammunition	**smuggler**	was sentenced on Wednesday to more than 11 years in

Figure 4-4: Concordance Results

By default, the windows are sorted by words before the target term. The algorithm looks to the first word before the target term, and if there is a match, it looks to the second word and so on. For example, "a" comes before "alien," and "paid" comes before "to." There are several other sorting options as shown in Figure 4-5.

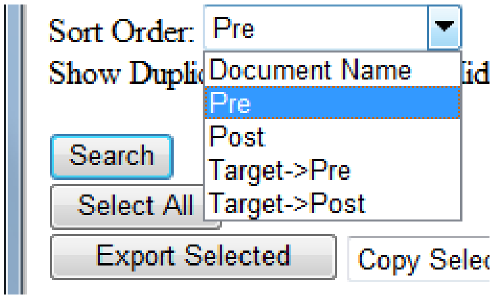

Figure 4-5: Concordance Sort Menu Options

As mentioned, the default is "Pre." One can also sort on words after the target term ("Post"). One can sort on the target term and then the words before it if there is a match ("Target->Pre"); one can sort on the target term and then the words before it if there is a match ("Target->Post"); one can sort by the "Document Name." Finally, if the indexer was able to load dates for the

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documents either through the file names or the directory structure, one can sort by document date. These sort orders will work for both left-to-right languages and right-to-left languages.

In addition to controlling the sort order, the user may select “Show Duplicate Windows” or “Hide Duplicate Windows.” If “Show Duplicate Windows” is selected, all windows will be shown. However, if “Hide Duplicate Windows” is selected, only the first unique window is shown. For this purpose, we say that one window is a duplicate of another if all of the alphanumeric characters are exactly the same and in the same order. If there is an extra “a” in one, both windows would appear because one is not a “duplicate” of another. This option has nothing to do with windows that appear in the same document. If you only want one row per document, use Basic Search.

The “Copy Selected” feature works exactly for concordance search as it does for basic search.

4.2.2 Concordance Search: Advanced, Filter Query

The general concordance query parser works well for most use cases. However, there are some limitations, including:

1. The concordance query parser can only search one field.
2. The concordance query parser cannot handle range queries.
3. The concordance query parser cannot perform a Boolean “NOT” search.
4. The concordance query parser cannot perform a Boolean “AND” search across terms that are not in the same phrase.

There are times when a user may want to see a target term in only a subset of documents. For example, a user may want to see “smuggler” in the concordance but only in documents that contain “cocaine.” To accomplish this type of search, we have made available the "Filter Query" window (see Figure 4-6). Rhapsode applies the basic Lucene query parser to this query (see section 5.1 below) to identify a subset of documents from which to build the concordance.

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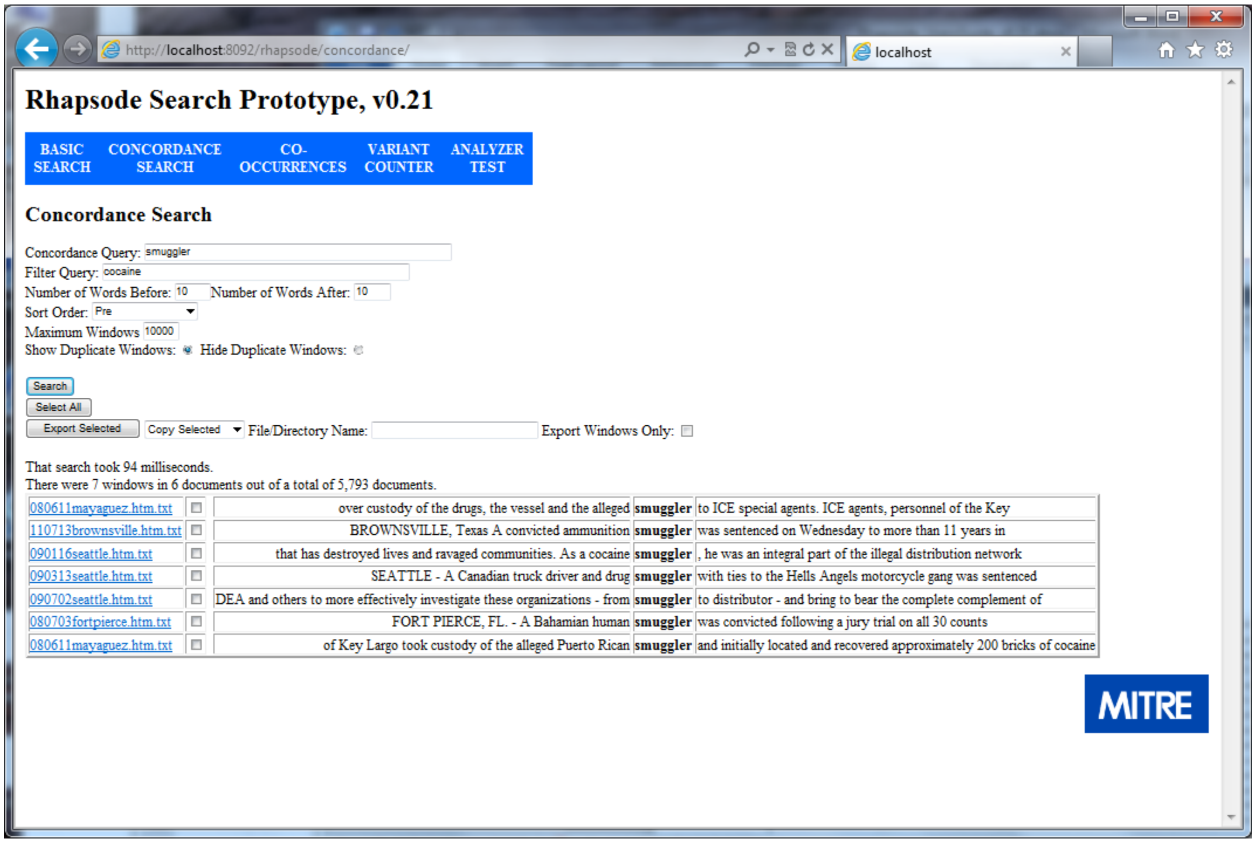

Rhapsode Search Prototype, v0.21

Concordance Search

Concordance Query: smuggler
Filter Query: cocaine
Number of Words Before: 10 Number of Words After: 10
Sort Order: Pre
Maximum Windows 10000
Show Duplicate Windows: ● Hide Duplicate Windows: ○

File/Directory Name: Export Windows Only: ☐

That search took 94 milliseconds.
There were 7 windows in 6 documents out of a total of 5,793 documents.

080611mayaguez.htm.txt	☐	over custody of the drugs, the vessel and the alleged	**smuggler**	to ICE special agents. ICE agents, personnel of the Key
110713brownsville.htm.txt	☐	BROWNSVILLE, Texas A convicted ammunition	**smuggler**	was sentenced on Wednesday to more than 11 years in
090116seattle.htm.txt	☐	that has destroyed lives and ravaged communities. As a cocaine	**smuggler**	, he was an integral part of the illegal distribution network
090313seattle.htm.txt	☐	SEATTLE - A Canadian truck driver and drug	**smuggler**	with ties to the Hells Angels motorcycle gang was sentenced
090702seattle.htm.txt	☐	DEA and others to more effectively investigate these organizations - from	**smuggler**	to distributor - and bring to bear the complete complement of
080703fortpierce.htm.txt	☐	FORT PIERCE, FL. - A Bahamian human	**smuggler**	was convicted following a jury trial on all 30 counts
080611mayaguez.htm.txt	☐	of Key Largo took custody of the alleged Puerto Rican	**smuggler**	and initially located and recovered approximately 200 bricks of cocaine

Figure 4-6: Concordance Search with a Filter Query

4.2.3 Exporting Concordance Results

The concordance searcher has exactly the same export options as the basic searcher.

4.3 Co-Occurrences

4.3.1 Co-Occurrences Basic

This tool runs the concordance searcher in the background, and it counts the terms that appear before and after the target term. For example, let's say that the user is interested in brands of counterfeit merchandise and searches on "gucci." The concordance results are shown in Figure 4-7.

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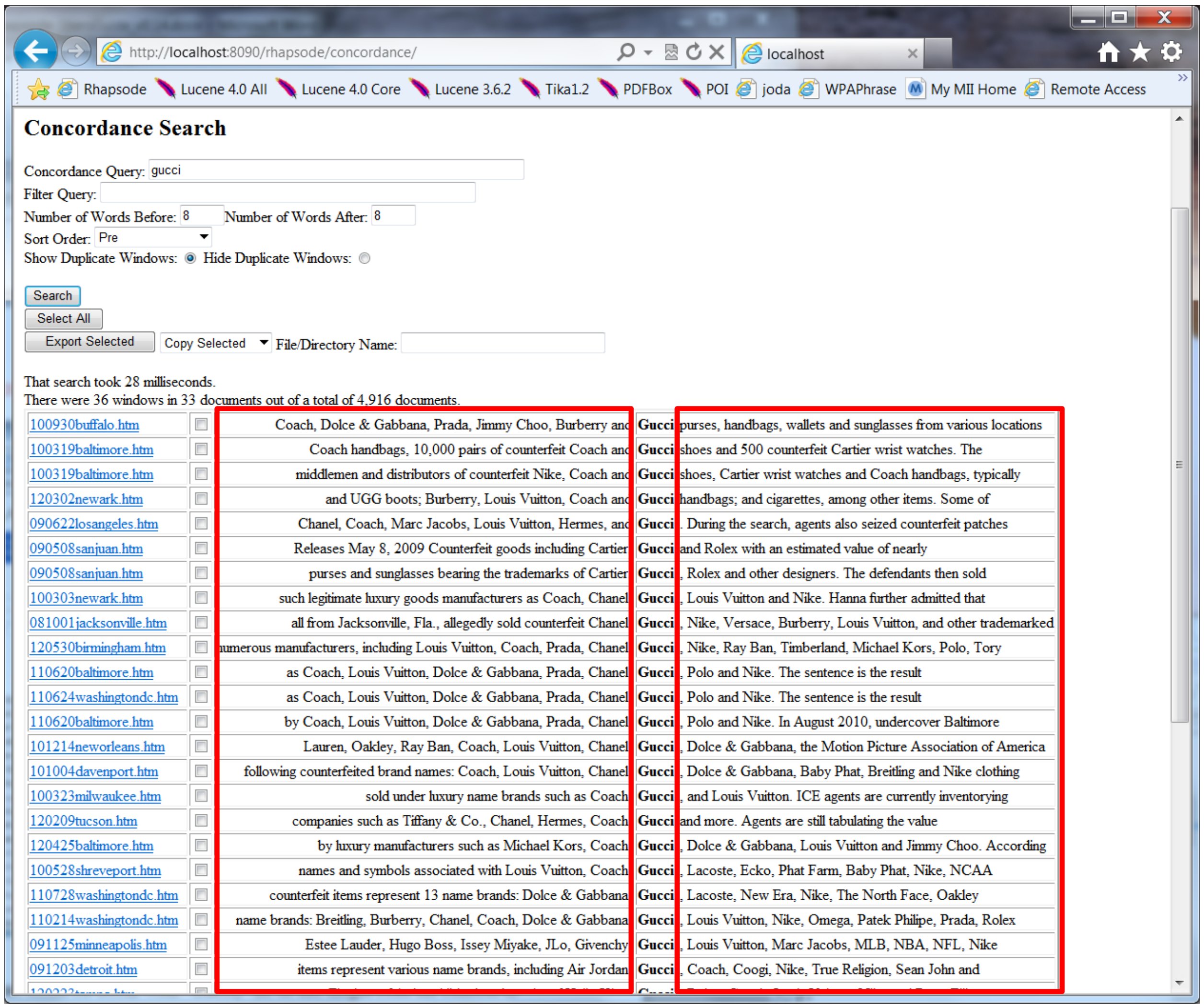

Concordance Search

Concordance Query: gucci
Filter Query:
Number of Words Before: 8 Number of Words After: 8
Sort Order: Pre
Show Duplicate Windows: ● Hide Duplicate Windows: ○

File/Directory Name:

That search took 28 milliseconds.
There were 36 windows in 33 documents out of a total of 4,916 documents.

100930buffalo.htm	☐	Coach, Dolce & Gabbana, Prada, Jimmy Choo, Burberry and	**Gucci**	purses, handbags, wallets and sunglasses from various locations
100319baltimore.htm	☐	Coach handbags, 10,000 pairs of counterfeit Coach and	**Gucci**	shoes and 500 counterfeit Cartier wrist watches. The
100319baltimore.htm	☐	middlemen and distributors of counterfeit Nike, Coach and	**Gucci**	shoes, Cartier wrist watches and Coach handbags, typically
120302newark.htm	☐	and UGG boots; Burberry, Louis Vuitton, Coach and	**Gucci**	handbags; and cigarettes, among other items. Some of
090622losangeles.htm	☐	Chanel, Coach, Marc Jacobs, Louis Vuitton, Hermes, and	**Gucci**	. During the search, agents also seized counterfeit patches
090508sanjuan.htm	☐	Releases May 8, 2009 Counterfeit goods including Cartier	**Gucci**	and Rolex with an estimated value of nearly
090508sanjuan.htm	☐	purses and sunglasses bearing the trademarks of Cartier	**Gucci**	, Rolex and other designers. The defendants then sold
100303newark.htm	☐	such legitimate luxury goods manufacturers as Coach, Chanel	**Gucci**	, Louis Vuitton and Nike. Hanna further admitted that
081001jacksonville.htm	☐	all from Jacksonville, Fla., allegedly sold counterfeit Chanel	**Gucci**	, Nike, Versace, Burberry, Louis Vuitton, and other trademarked
120530birmingham.htm	☐	numerous manufacturers, including Louis Vuitton, Coach, Prada, Chanel	**Gucci**	, Nike, Ray Ban, Timberland, Michael Kors, Polo, Tory
110620baltimore.htm	☐	as Coach, Louis Vuitton, Dolce & Gabbana, Prada, Chanel	**Gucci**	, Polo and Nike. The sentence is the result
110624washingtondc.htm	☐	as Coach, Louis Vuitton, Dolce & Gabbana, Prada, Chanel	**Gucci**	, Polo and Nike. The sentence is the result
110620baltimore.htm	☐	by Coach, Louis Vuitton, Dolce & Gabbana, Prada, Chanel	**Gucci**	, Polo and Nike. In August 2010, undercover Baltimore
101214neworleans.htm	☐	Lauren, Oakley, Ray Ban, Coach, Louis Vuitton, Chanel	**Gucci**	, Dolce & Gabbana, the Motion Picture Association of America
101004davenport.htm	☐	following counterfeited brand names: Coach, Louis Vuitton, Chanel	**Gucci**	, Dolce & Gabbana, Baby Phat, Breitling and Nike clothing
100323milwaukee.htm	☐	sold under luxury name brands such as Coach	**Gucci**	, and Louis Vuitton. ICE agents are currently inventorying
120209tucson.htm	☐	companies such as Tiffany & Co., Chanel, Hermes, Coach	**Gucci**	and more. Agents are still tabulating the value
120425baltimore.htm	☐	by luxury manufacturers such as Michael Kors, Coach	**Gucci**	, Dolce & Gabbana, Louis Vuitton and Jimmy Choo. According
100528shreveport.htm	☐	names and symbols associated with Louis Vuitton, Coach	**Gucci**	, Lacoste, Ecko, Phat Farm, Baby Phat, Nike, NCAA
110728washingtondc.htm	☐	counterfeit items represent 13 name brands: Dolce & Gabbana	**Gucci**	, Lacoste, New Era, Nike, The North Face, Oakley
110214washingtondc.htm	☐	name brands: Breitling, Burberry, Chanel, Coach, Dolce & Gabbana	**Gucci**	, Louis Vuitton, Nike, Omega, Patek Philipe, Prada, Rolex
091125minneapolis.htm	☐	Estee Lauder, Hugo Boss, Issey Miyake, JLo, Givenchy	**Gucci**	, Louis Vuitton, Marc Jacobs, MLB, NBA, NFL, Nike
091203detroit.htm	☐	items represent various name brands, including Air Jordan	**Gucci**	, Coach, Coogi, Nike, True Religion, Sean John and

Figure 4-7: Concordance Results for "gucci"

If the user is interested in what terms co-occur with “Gucci,” he or she might read the context to get a sense of the terms, or he could use the Co-Occurrences tool to count terms that appear within a window of the target term. See Figure 4-8 for the results. The results are sorted by a classic (and simple) measure of interestingness, known as term frequency * inverse document frequency or TF*IDF. See section 4.3.2 below for a discussion of inverse document frequency.

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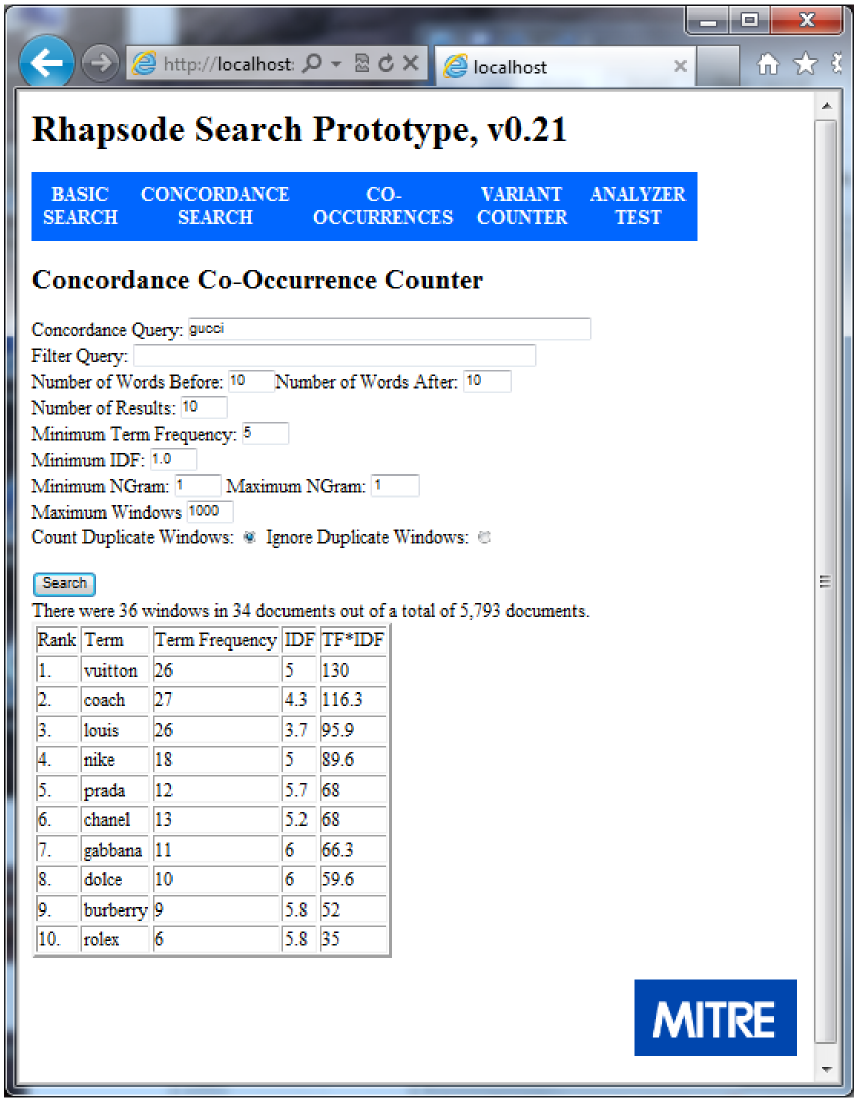

Rhapsode Search Prototype, v0.21

Concordance Co-Occurrence Counter

Concordance Query: gucci
Filter Query:
Number of Words Before: 10 Number of Words After: 10
Number of Results: 10
Minimum Term Frequency: 5
Minimum IDF: 1.0
Minimum NGram: 1 Maximum NGram: 1
Maximum Windows 1000
Count Duplicate Windows: [✓] Ignore Duplicate Windows:

There were 36 windows in 34 documents out of a total of 5,793 documents.

Rank	Term	Term Frequency	IDF	TF*IDF
1.	vuitton	26	5	130
2.	coach	27	4.3	116.3
3.	louis	26	3.7	95.9
4.	nike	18	5	89.6
5.	prada	12	5.7	68
6.	chanel	13	5.2	68
7.	gabbana	11	6	66.3
8.	dolce	10	6	59.6
9.	burberry	9	5.8	52
10.	rolex	6	5.8	35

Figure 4-8: Co-Occurrences with "gucci"

As with the Concordance Search, the user selects a query, optionally a filter query, the number of words before and the number of words after; and the user may choose to ignore duplicate windows or count duplicate windows as in the basic Concordance Search. However, the options vary slightly for a Co-occurrences search. The user may modify the number of results to see. The user may modify the minimum term frequency of terms for consideration; for example, the user could require that a term co-occur 5 times with the target term before it might appear in the list. The user may modify the minimum IDF; for example, the user may want to rule out common words (those with a low IDF) as potential candidates. The user may modify the minimum phrasal size (known as an “ngram”) and the maximum phrasal size. For example, the user may want to see phrases that have two or more words and fewer than four words; to accomplish this, the user would enter “2” in the “Minimum NGram” box and “4” in the “Maximum NGram” box. As we show in Figure 4-9, it is sometimes useful to capture phrases;

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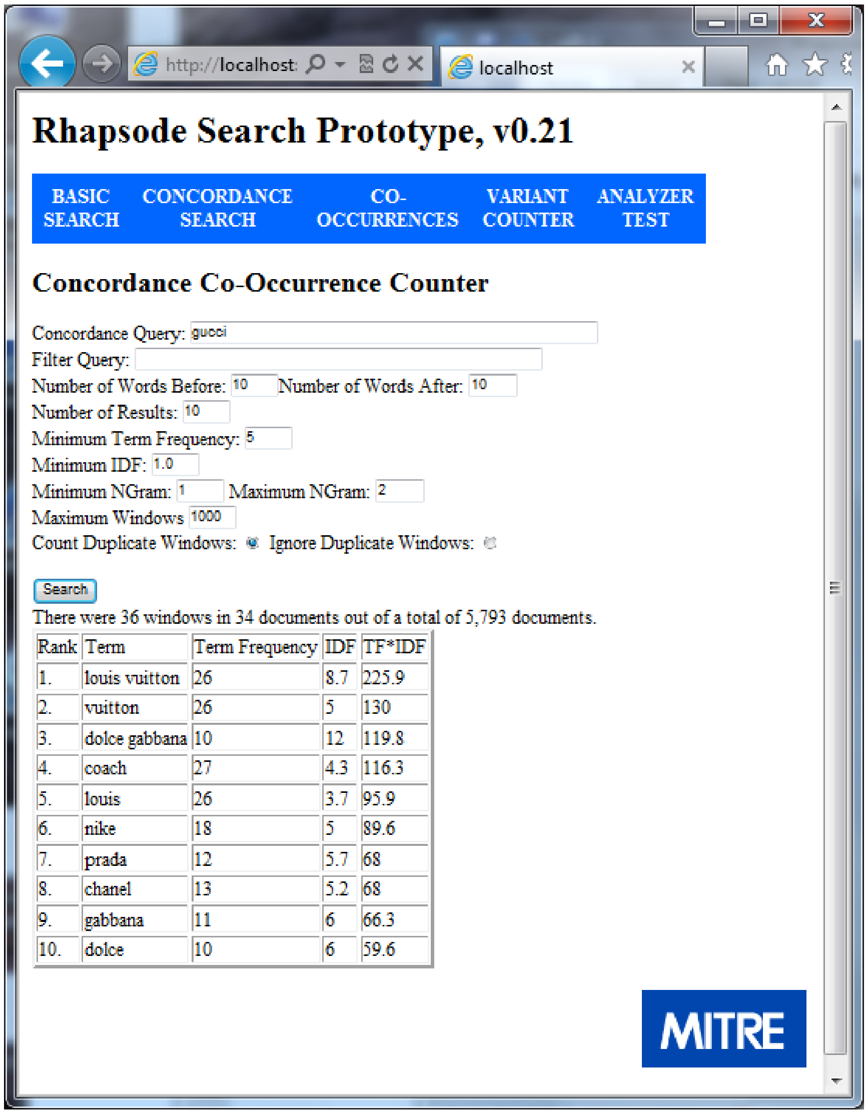
this is especially true in non-whitespace languages and other languages that tend to be more phrasal than English, such as Persian.



Rhapsode Search Prototype, v0.21

Concordance Co-Occurrence Counter

Concordance Query: gucci
Filter Query:
Number of Words Before: 10 Number of Words After: 10
Number of Results: 10
Minimum Term Frequency: 5
Minimum IDF: 1.0
Minimum NGram: 1 Maximum NGram: 2
Maximum Windows 1000
Count Duplicate Windows: ● Ignore Duplicate Windows: ○

There were 36 windows in 34 documents out of a total of 5,793 documents.

Rank	Term	Term Frequency	IDF	TF*IDF
1.	louis vuitton	26	8.7	225.9
2.	vuitton	26	5	130
3.	dolce gabbana	10	12	119.8
4.	coach	27	4.3	116.3
5.	louis	26	3.7	95.9
6.	nike	18	5	89.6
7.	prada	12	5.7	68
8.	chanel	13	5.2	68
9.	gabbana	11	6	66.3
10.	dolce	10	6	59.6

Figure 4-9: Co-Occurrences that are Single Terms or Two Word Phrases

One main caveat to this tool is that it is very simple and is only counting words. Users should not rely on its output as if Rhapsode understood what it is reading. I've cherry-picked the examples above to show how well this technique *can* work. For some query terms in some corpora, many of the co-occurrences make no sense and/or may be useless or misleading from an analytical perspective. Use the results from this tool carefully!

There are currently two less serious but annoying issues with the phrasal search. First, the technique I implemented does not discount shorter terms after a longer term has been selected. For example, "louis" appears as a unigram even though it has already been counted in the phrase "louis vuitton." The other annoying issue is that "phrases" can appear that no human would

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judge to be a phrase, for example, “coach louis”. The solutions to both would require more computational power, and I’ve chosen lightweight for now.

Despite these limitations, this can be a useful tool as part of a larger analytical process.

4.3.2 Co-Occurrences: Advanced

The minimum IDF option is straightforward if the user is only searching for single terms. However, if the user is searching for phrases (ngrams with $n > 1$), Rhapsode actually computes wgrams.[2] One way to think of a wgram is as an ngram, where there are n terms; w of them must be above the IDF threshold, and the phrase must neither start nor end with a word below the threshold. In other words, a wgram can neither begin nor end with a term that has lower than the threshold IDF; for example, if the minimum IDF were 1.0, then “bank of” would probably be rejected as a wgram because “of” typically has a lower IDF than 1.0. Further, a wgram does not count internal words that fall below the IDF threshold towards the n. For example, again with an IDF of 1.0, “Bank of America” would be counted as a two word phrase or a bigram.

If your index has multiple languages, this simple TF*IDF method can yield poor results. For this purpose, if possible, it is better to construct a separate index for each language.

4.4 Variant Counter

4.4.1 Variant Counter: Basic

Behind the scenes, Lucene expands fuzzy queries (for example: `f?x`) into the actual terms in the index. It is often helpful to see how Lucene is expanding the queries. This is also a helpful way to learn about spelling variants in your index. If you are only interested in the variants of a single term, click on the “Simple Single Term Search” option. This is the fastest option, and it will return document frequencies. If the user is interested in searching for phrasal variants, or if the user wants the term frequencies in addition to the document frequencies, select “Advanced Search.”

[2] The “w” stands for Wilson, as in George V. Wilson, my colleague who explained this idea to me.

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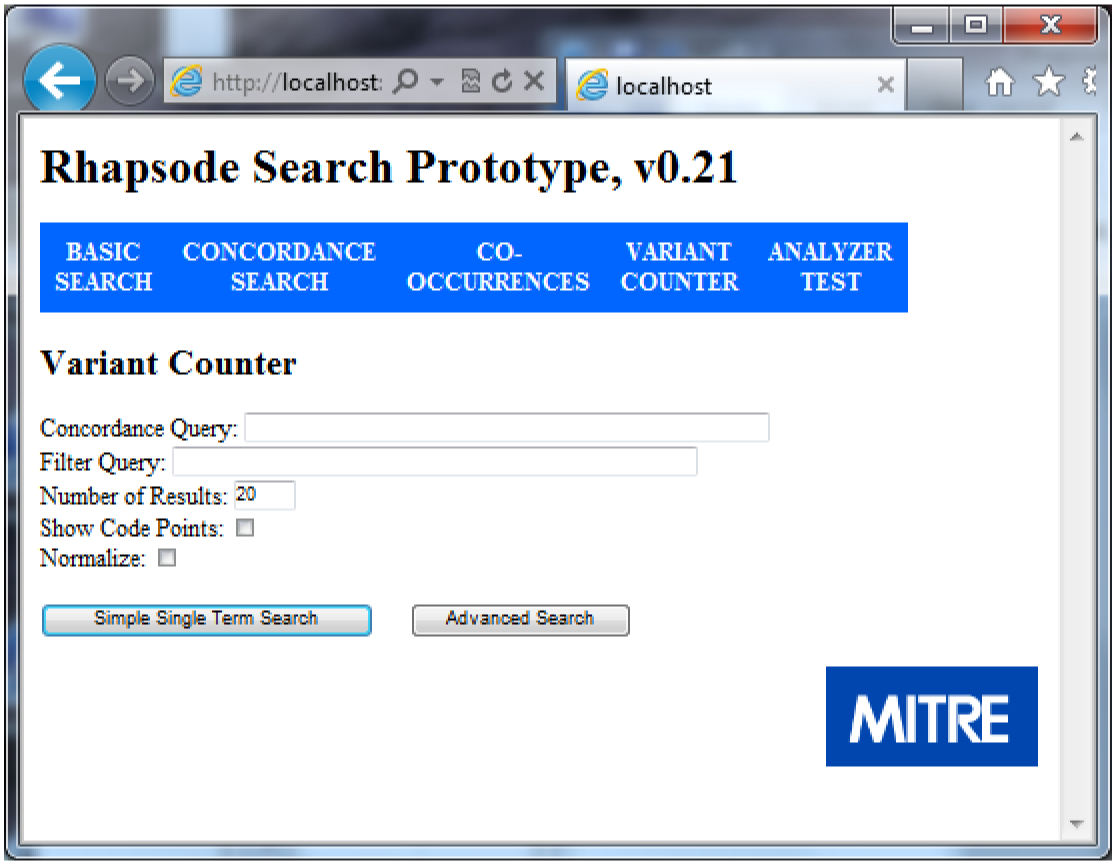
Rhapsode Search Prototype, v0.21

BASIC SEARCH | CONCORDANCE SEARCH | CO-OCCURRENCES | VARIANT COUNTER | ANALYZER TEST

Variant Counter

Concordance Query:
Filter Query:
Number of Results: 20
Show Code Points: ☐
Normalize: ☐

Figure 4-10: Variant Counter Main Window

In Figure 4-11, we show the results for a fuzzy query of "mohammad." The output of the variant counter also includes the number of documents in which the term appears, and it includes the inverse document frequency (IDF).[3]

[3] The formula for IDF in Rhapsode is ln((TotalNumberOfDocuments+1)/NumberOfDocumentsWithTargetTerm). I add one to the total number of documents so that IDF is never 0.

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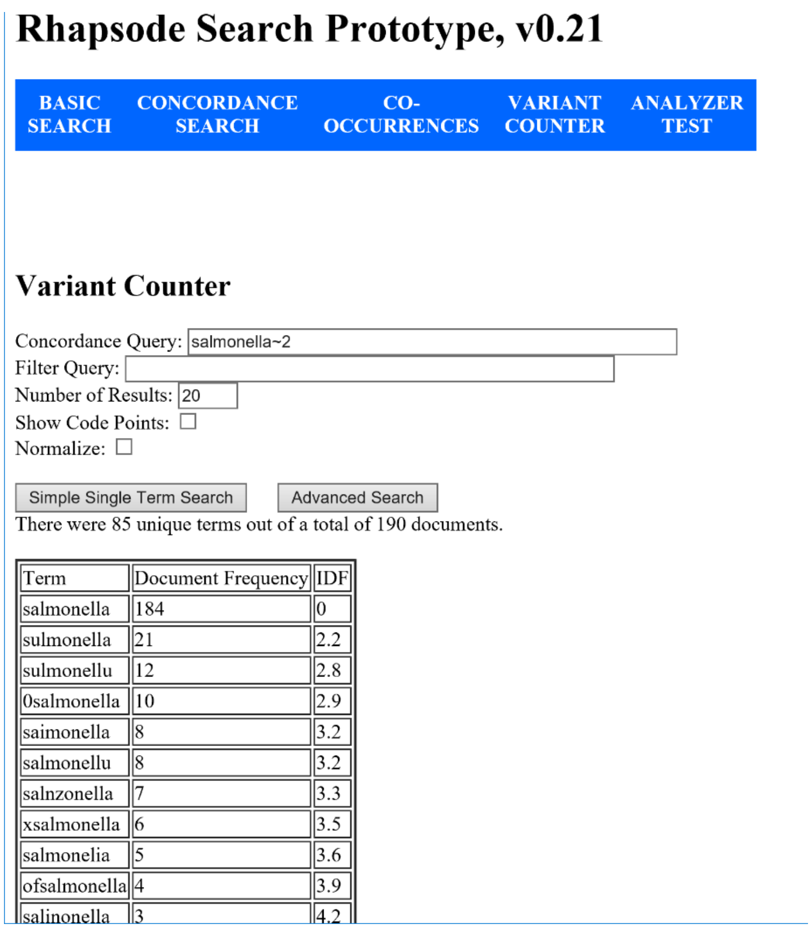
Rhapsode Search Prototype, v0.21

Variant Counter

Concordance Query: salmonella~2
Filter Query:
Number of Results: 20
Show Code Points: ☐
Normalize: ☐

There were 85 unique terms out of a total of 190 documents.

Term	Document Frequency	IDF
salmonella	184	0
sulmonella	21	2.2
sulmonellu	12	2.8
0salmonella	10	2.9
saimonella	8	3.2
salmonellu	8	3.2
salnzonella	7	3.3
xsalmonella	6	3.5
salmonelia	5	3.6
ofsalmonella	4	3.9
salinonella	3	4.2

Figure 4-11: Results from the Variant Counter

In the above example, if the user is satisfied with how the fuzzy term is being expanded, he may use the fuzzy term as it is in the query. However, sometimes a fuzzy term captures more variants than the user intends, and in this case, the user may copy only those spelling variants that are relevant to the query and then use those variants.

4.4.2 Variant Counter (Advanced)

As described above, the "Simple Single Term Search," works on only a single term, and it returns only the document frequencies for the variants. If the user selects the "Advanced Search" button, Rhapsode will run a concordance search in the background and count the variants of the target. In Figure 4-12, we show the results from that type of search. Notice that there are different capitalizations. If the "Normalize" checkbox is not checked, Rhapsode will return the literal strings as they appear in the documents (Figure 4-12). If the "Normalize" checkbox is checked, Rhapsode will normalize the results, as we show in Figure 4-13.

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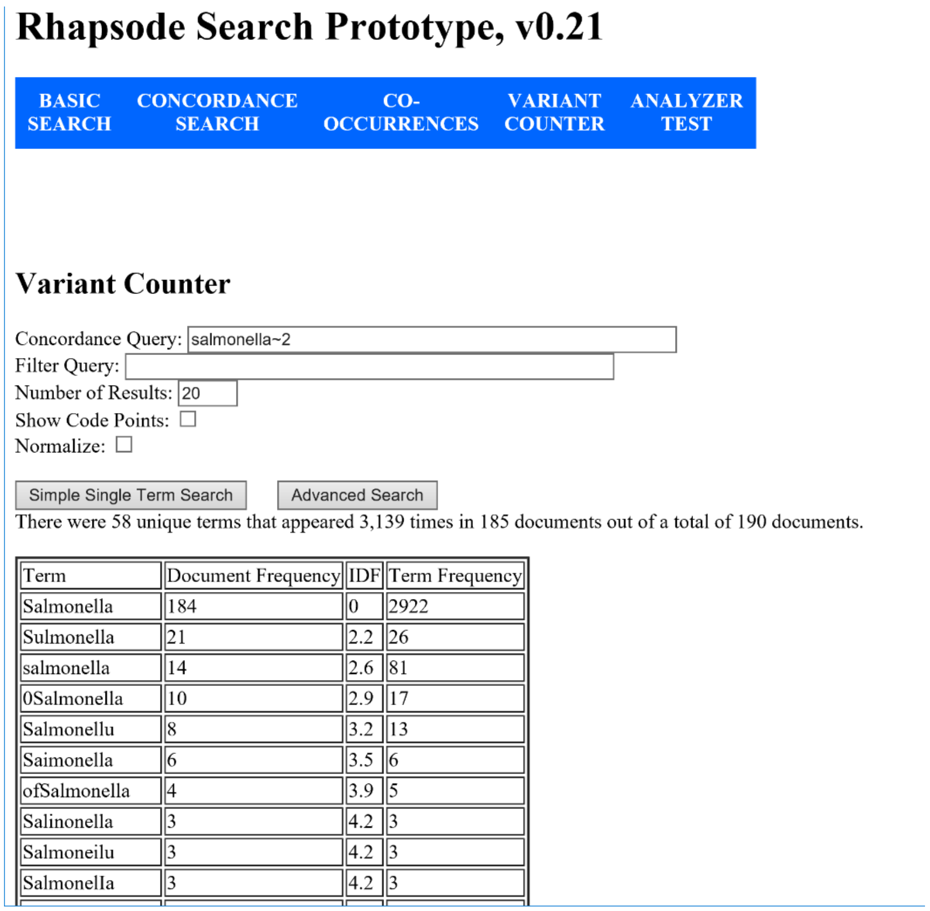

Concordance Query: salmonella~2
Filter Query:
Number of Results: 20
Show Code Points: ☐
Normalize: ☐

There were 58 unique terms that appeared 3,139 times in 185 documents out of a total of 190 documents.

Term	Document Frequency	IDF	Term Frequency
Salmonella	184	0	2922
Sulmonella	21	2.2	26
salmonella	14	2.6	81
0Salmonella	10	2.9	17
Salmonellu	8	3.2	13
Saimonella	6	3.5	6
ofSalmonella	4	3.9	5
Salinonella	3	4.2	3
Salmoneilu	3	4.2	3
SalmonelIa	3	4.2	3

Figure 4-12: Results from the "Advanced Search" Button in the Variant Counter

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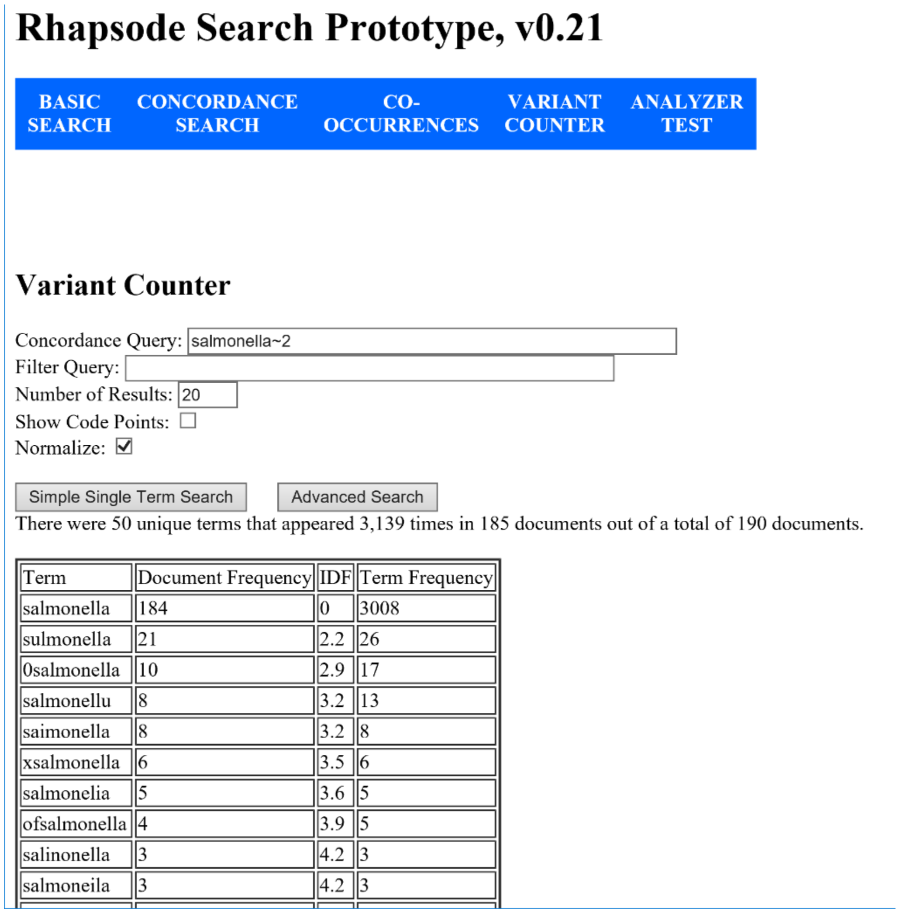

Rhapsode Search Prototype, v0.21

Variant Counter

Concordance Query: salmonella~2
Filter Query:
Number of Results: 20
Show Code Points: ☐
Normalize: ☑

There were 50 unique terms that appeared 3,139 times in 185 documents out of a total of 190 documents.

Term	Document Frequency	IDF	Term Frequency
salmonella	184	0	3008
sulmonella	21	2.2	26
0salmonella	10	2.9	17
salmonellu	8	3.2	13
saimonella	8	3.2	8
xsalmonella	6	3.5	6
salmonelia	5	3.6	5
ofsalmonella	4	3.9	5
salinonella	3	4.2	3
salmoneila	3	4.2	3

Figure 4-13: Results from the "Advanced Search" Button with “Normalize” Checked in the Variant Counter

If the user is interested in searching for phrasal variants, such as (find a variant of “Adam” within three words before “Barguthi”), the user would enter [adham~1 barguthi~2]~>3, and then click the “Advanced Search” button. As we show in Figure 4-14, there are two variants. In the first, the first name has no “h” and a middle name, and in the second variant, the first name has an extra “h” and no middle name.

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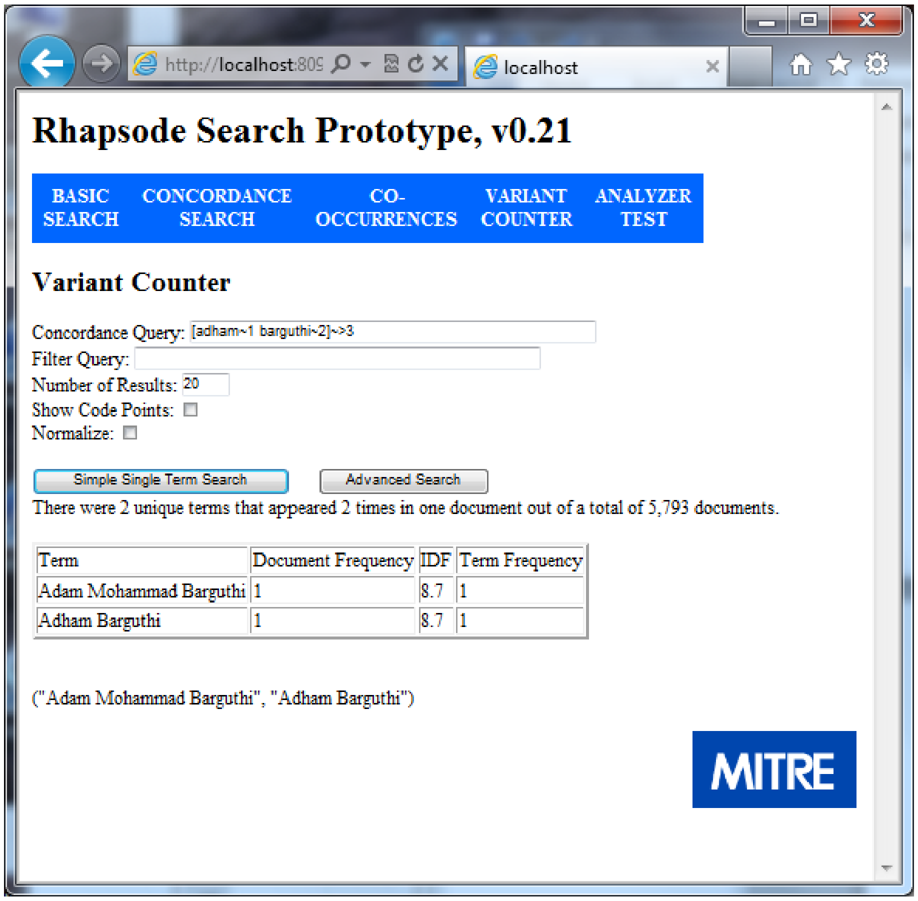

Concordance Query: [adham~1 barguthi~2]~>3
Filter Query:
Number of Results: 20
Show Code Points: ☐
Normalize: ☐

There were 2 unique terms that appeared 2 times in one document out of a total of 5,793 documents.

Term	Document Frequency	IDF	Term Frequency
Adam Mohammad Barguthi	1	8.7	1
Adham Barguthi	1	8.7	1

("Adam Mohammad Barguthi", "Adham Barguthi")

Figure 4-14: Example of a Phrasal Variant Search

Finally, the user may be interested in seeing variants that may not be visible in the presentation form. In Figure 4-15, we show the results of searching for the Persian word for "America" in a fairly large corpus. Note that we have entered a single non-fuzzy term in the query box. We have not selected "Normalize," and we have selected "Show Code Points." The results show that there are 17 different combinations of Unicode code points for the word "America." If the indexer and the query parser had not used Unicode normalization, there would have been only one "variant." The user is also able to see the exact Unicode code points that appear in the text.

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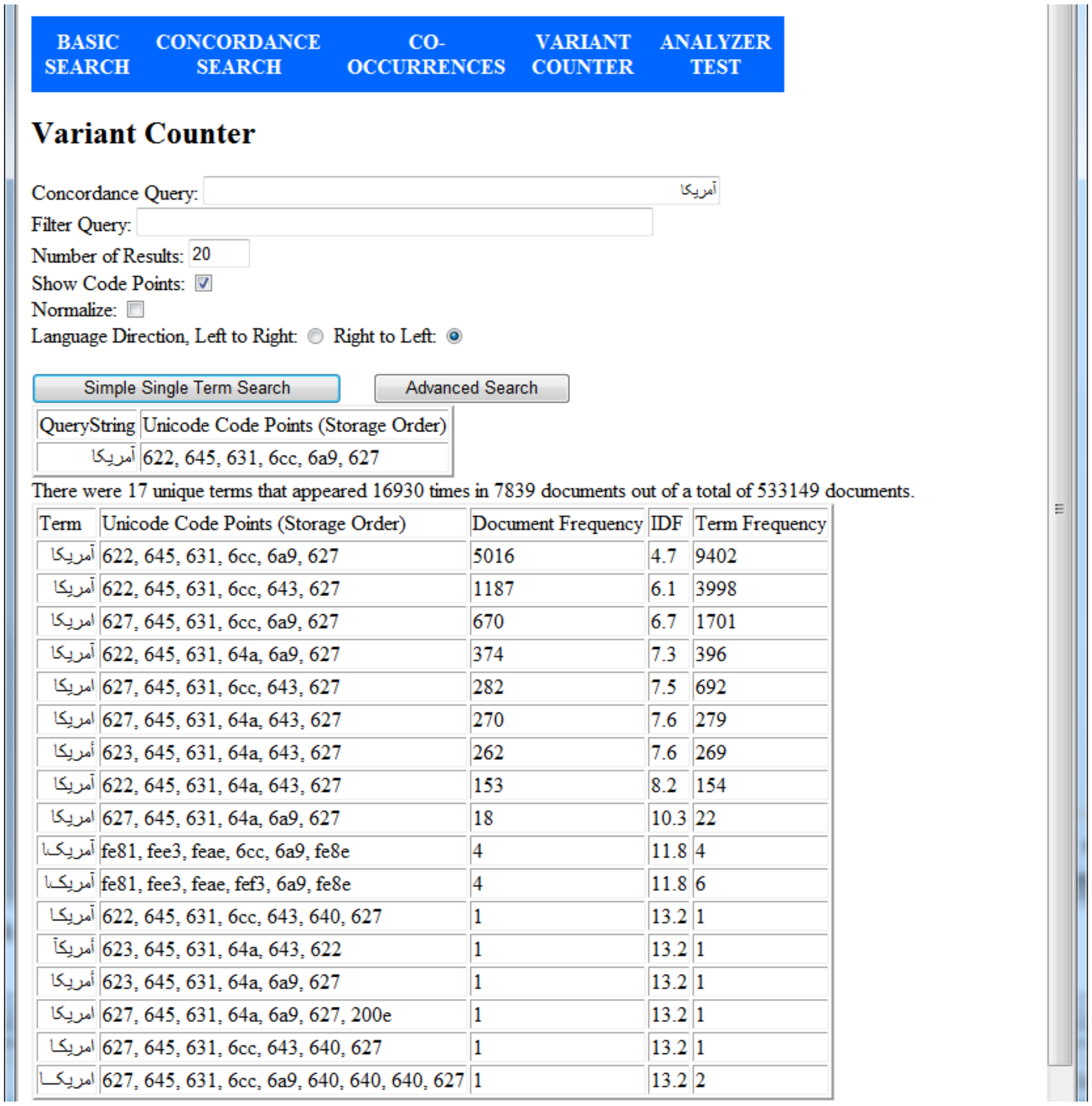

Variant Counter

Concordance Query: آمریکا
Filter Query:
Number of Results: 20
Show Code Points: ☑
Normalize: ☐
Language Direction, Left to Right: ○ Right to Left: ●

QueryString	Unicode Code Points (Storage Order)
آمریکا	622, 645, 631, 6cc, 6a9, 627

There were 17 unique terms that appeared 16930 times in 7839 documents out of a total of 533149 documents.

Term	Unicode Code Points (Storage Order)	Document Frequency	IDF	Term Frequency
آمریکا	622, 645, 631, 6cc, 6a9, 627	5016	4.7	9402
آمریكا	622, 645, 631, 6cc, 643, 627	1187	6.1	3998
امریکا	627, 645, 631, 6cc, 6a9, 627	670	6.7	1701
آمريکا	622, 645, 631, 64a, 6a9, 627	374	7.3	396
امریكا	627, 645, 631, 6cc, 643, 627	282	7.5	692
امريكا	627, 645, 631, 64a, 643, 627	270	7.6	279
أمريكا	623, 645, 631, 64a, 643, 627	262	7.6	269
آمريكا	622, 645, 631, 64a, 643, 627	153	8.2	154
امريکا	627, 645, 631, 64a, 6a9, 627	18	10.3	22
ﺁﻣﺮیکﺎ	fe81, fee3, feae, 6cc, 6a9, fe8e	4	11.8	4
ﺁﻣﺮﻳکﺎ	fe81, fee3, feae, fef3, 6a9, fe8e	4	11.8	6
آمریكـا	622, 645, 631, 6cc, 643, 640, 627	1	13.2	1
أمريكآ	623, 645, 631, 64a, 643, 622	1	13.2	1
أمريکا	623, 645, 631, 64a, 6a9, 627	1	13.2	1
امريکا‎	627, 645, 631, 64a, 6a9, 627, 200e	1	13.2	1
امریكـا	627, 645, 631, 6cc, 643, 640, 627	1	13.2	1
امریکـــا	627, 645, 631, 6cc, 6a9, 640, 640, 640, 627	1	13.2	2

Figure 4-15: Unicode Variants of "America" in Persian

5. Query Parser Syntax

As of version 0.30 of Rhapsode, there is one query syntax available in both the main query window and the filter query window. In earlier versions, there were subtly different parser syntax options in the different windows.

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5.1 Query Parser Syntax

A useful tutorial for this syntax is available here:
http://lucene.apache.org/core/old_versioned_docs/versions/3_0_0/queryparsersyntax.html

In the following, we show some of the highlights.

5.1.1 Key word Query

Find documents that contain “mississippi”:

```
mississippi
```

5.1.2 Fuzzy Query

Find documents that contain a term that differs by two key strokes from the target term:

```
mississippi~2
```

5.1.3 Wildcard Query

Find documents that contain a term with wildcards: “?” means any one character and “*” means zero or any number of characters.

Find documents that match “mississippi” or “missippi”

```
miss*ppi
```

Find documents that match matches only “missippi”

```
miss?ppi
```

5.1.4 Boolean Query

Find documents that contain “mississippi” but don’t contain “barbecue”

```
+mississippi -barbecue
```

Find documents that contain “Memphis” or “Mississippi” and “barbecue”

```
+(mississippi memphis) +barbecue
```

5.1.5 Phrasal searches

Find documents that include a phrase such as “mississippi barbecue”

```
"mississippi barbecue"
```

Find documents that include “Mississippi” within 5 words of “barbecue.” The term “barbecue” could appear before or after “Mississippi.”

```
"Mississippi barbecue"~5
```

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5.1.6 Range Searches

If your input documents are in directories that identify the year and month for the documents (Figure 5-1), you can search for a range of dates.

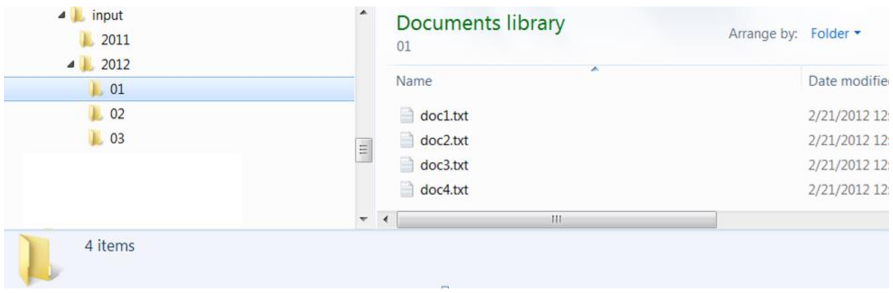

Figure 5-1: Directory Structure with Optional Date Hierarchy

For example, to find "barbecue" documents ranging from June, 2011 to February, 2012, the query would be:

```
+barbecue +date:[201106 TO 201202]
```

The "+" signs mean that both have to be true. Make sure that "TO" is capitalized in the range search.

5.1.7 Regular Expression Searches

In addition to the fuzzy search and the wildcard search, the concordance query parser can parse term-level regular expressions. With regular expressions, users can search with finer grained detail than with wildcard searching. For example, find "cat" or "cut" but not "cot":

```
     c[au]t
```

A quick tutorial for regular expressions is available here: http://www.regular-expressions.info/quickstart.html. For a full tutorial on regular expressions, see (http://www.regular-expressions.info/tutorial.html). Note that the regular expressions only work on a per term basis within the Lucene framework. It is not possible to use regular expressions to search for one term near another. For example, this will not work:

```
     /mississippi(\W+\w+){0,5}\W+barbecue/
```

5.1.8 Directional Phrasal Searches

In the traditional Lucene query parser syntax, it is not possible to require directionality if one is using slop. We have added syntax to allow the user to require that one term come before another. For example, find "barbecue" within 5 words **after** "mississippi:"

```
"mississippi barbecue"~>5
```

5.1.9 Recursive phrasal searches

Find a fuzzy match on "Mississippi" within 5 words of a regular expression for "barbecue":

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```
[mississippi~2 /barbecue|bbq/]~5
```

To capture recursive phrasal searches, we have added square brackets as an optional way to mark the beginning and the end of a phrase. For example, find "Mississippi" or "Memphis" within 5 words of "barbecue," and that match should occur 10 words before "competition:"

```
[[(mississippi memphis) barbecue]~5 competition]~>10
```

5.1.10 Important Caveats

- As of version 0.20, it is now possible to specify a negative filter query. To find all documents that do not contain "miami", type the following in the filter query window. `NOT miami`

  "NOT" must come first, and it must be fully capitalized.

- Behind the scenes, Lucene expands the wild card and fuzzy queries into matching terms from the index and then creates a Boolean query. For example, if the query is "`f?x`", Lucene will search the index for terms that match that query, and it will convert this wildcard query to the Boolean query `"fax"` or `"fox"`. In a large index, if a user searches for `"a*"`, the Boolean query would contain thousands of terms. In Lucene's documentation, the limit on the number of terms in a query is 1024. If the expanded query contains more than that number of terms, you should receive a parse exception error message. In one test we ran, however, with 1500 terms, we did not receive the error.

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