Where the #@*! is That?: The Art of the Text Query

Let's say law enforcement needs to locate all references to "incendiary devices" in a computerized stack of documents.

Or MegaHugeCorp is planning a merger with GigaHugeCorp, and the Federal Trade Commission has asked MegaHugeCorp for all materials on file relating to "marketplace competitive analysis."

Or let's say that during a high-speed chase through the streets of Prague, a CIA operative is able to wrest a single typed paragraph out of the hands of a suspected member of a terrorist organization. The CIA needs to find other possible matches to this text from millions of satellite and wire intercepts.

Or let's say the whole family is coming to dinner, and you need the blueberry pie recipe you typed into your laptop last year.

In the first scenario, the obvious text search is for *incendiary devices*, while in the CIA case a search for a few keywords from the stolen paragraph might work. In the MegaHugeCorp case, *marketplace competitive analysis* might be the search. And to locate the pie, the obvious search string is *blueberry*.

> How can dtSearch,® for example, search over terabytes of text in less than a second? It does so by building an index that stores the location of each word within a document. Once an index is complete, search time is generally less than a second, even through millions of files.

And these searches would yield ... NOTHING! No "incendiary devices" in the first scenario. Nothing in the merger case: "I'm sorry Federal Trade Commission, but we've remarkably gotten to dominate our marketplace without any apparent thought to 'marketplace competitive analysis.'" Nothing in the blueberry pie example: "I knew my dog was eating computer files!" And in the CIA case, 42

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billion documents, which is far too many retrieved documents for even a pack of trained chimps to thumb through.

This is where advanced query techniques, available in dtSearch,® for example, are helpful. In the "incendiary devices" case, concept searching and stemming provide the solution. In the merger case, Boolean and proximity searching do the trick. In the CIA case, the solution is relevancy-ranked natural language searching and variable term weighting. And in the blueberry pie case, the answer is fuzzy searching because you misspelled *blueberry*.

Concept Searching and Stemming

Concept searching, also known as synonym or thesaurus searching, expands a single search request into multiple conceptual dimensions. For example, with concept searching, a search for *incendiary* automatically expands (using the search program's built-in thesaurus) to include such synonyms as *arsonist* and *inflammatory*. Going broader into "related words" provides *combustible* and *bomb*.

An additional option is to find out the names of specific incendiary devices and enter them as synonyms in a user-defined addendum to the built-in thesaurus. The combined built-in thesaurus and user-defined thesaurus allows automatic synonym expansion covering a wide range of search terms, all with a simple search request.

Now, thanks to concept searching, it is easy to find every document that includes any synonym of *incendiary*. But what about derivatives of these words, such as *inflammatories* in addition to *inflammatory*? This type of expansion requires stemming.

Stemming uses a built-in algorithm that is familiar with the native language, in this case English, to expand a search request to include word derivatives automatically. A search for *apply* that includes stemming finds *applies*, *applied*, *applying*, but not *appliance*.

This brings up an important point of search request formation. When not highly familiar with the target documents (which is the case in all of the examples above, with the possible exception of the blueberry pie recipe), then cast the net broadly. But not too broadly. Choosing all words related to *incendiary*, or even all related words of related words, retrieves documents with terms no more relevant than *felon* or *outlaw*.

The fundamental principle of text queries is: when searching a very large and diverse database, as search completeness or retrieving all the potentially relevant information increases, so do "false hits" or the retrieval of irrelevant documents. Maximizing the chance of retrieving "the smoking gun" in a search, while minimizing the retrieval of irrelevant documents, requires casting the net just right.

Boolean, Phrase, Proximity, Wildcards, Field, Numeric Range

If concept searching and stemming were the only search tools, then it would be tough casting the net just right. Boolean operatives such as *and*, *or* and *not* help refine the search request. For example, in the merger scenario, a search for *market analysis or competitive analysis* is a basic Boolean search in combination with a phrase search. Such a search retrieves all documents that contain either the phrase *market analysis* or the phrase *competitive analysis* or both.

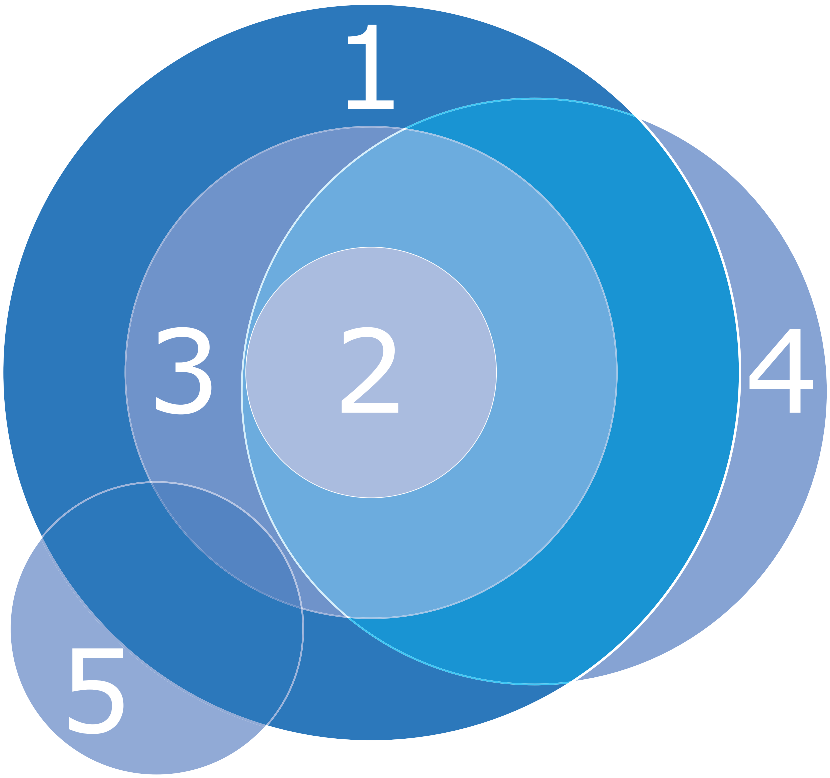
But what if you also need to find documents containing text such as: *the market that would be relevant for the analysis*. Finding that type of text requires *market* near *analysis* or *competitive* near *analysis*. How near? Let's say within 25 words, giving the resulting query: *(market or competitive) w/25 analysis*. This query finds all documents that contain either the term *market* or the term *competitive* relatively near to *analysis*.

Wildcards, which complement a Boolean search, include the question mark (?) for replacing a single letter in a word, and the asterisk (*) for replacing any number of letters in a word. Suppose MegaHugeCorp's previous names were MegaMediumCorp and MegaSmallCorp. A search for *Mega*Corp* retrieves all three. (Almost all text searches should be case insensitive. With the possible exception of source code searching, case-sensitive searches are usually a bad idea since they miss too many relevant words.)

Another element that works well with Boolean searches is numeric range searching, such as searching for any number between *11* and *127*. Field searching, or limiting a search to a specific document field, also works well with Boolean searching.

Combining Boolean searches with stemming and concept searching is also powerful. For example, with stemming on, the search request *(market or competitive) w/25 analysis* retrieves not only *market*, but also *markets* and *marketing*.

Subset, Superset, and "Anything But" Search Requests



1 *(market or competitive) w/25 analysis*
2 *((market or competitive) w/25 analysis) and not supermarket*
3 *((market or competitive) w/25 analysis) not w/75 supermarket*
4 *(((market or competitive) w/25 analysis) and not supermarket) or exclusionary*
5 *monopoly and not ((((market or competitive) w/25 analysis) and not supermarket) or exclusionary)*

Narrow, Broaden and Exclude

Although it is possible to arrive at a query such as *(market or competitive) w/25 analysis* through logical deduction alone, a dose of trial and error is often necessary. This is particularly true if a high degree of familiarity with the target database is lacking. In the merger scenario, it is unlikely that anyone has previously seen every single document relating to "marketplace competitive analysis."

Suppose the query *(market or competitive) w/25 analysis* finds a slew of documents pertaining to the analysis of supermarket shoppers. The documents date to a time when MegaHugeCorp considered offering its non-food wares in supermarkets but then rejected the idea. Because neither merging company presently sells through supermarkets, these documents fall outside of the Federal Trade Commission's document request.

Trial and error results in a narrowed search request: *((market or competitive) w/25 analysis) and not supermarket*. This finds the same document set as the previous search request, excluding all documents that contain the word *supermarket*. The search results represent a subset of the previous search. Alternatively, a search request that creates a slightly larger subset, by excluding only documents that contain the word *supermarket* within 75 words of the *market/competitive/analysis* cluster is: *((market or competitive) w/25 analysis) not w/75 supermarket*.

Suppose the search request *((market or competitive) w/25 analysis) and not supermarket* requires expansion to include the search term *exclusionary*. Broadening the search request creates a superset of the previous search. Effectively, this takes the previous search request and adds an "or" element: *(((market or competitive) w/25 analysis) and not supermarket) or exclusionary*.

Finally, after painstaking review of every retrieved document in the search request *(((market or competitive) w/25 analysis) and not supermarket) or exclusionary*, the legal department suggests adding the term *monopoly*. An "anything but" search such as *monopoly and not ((((market or competitive) w/25 analysis) and not supermarket) or exclusionary)* ensures retrieving only new files excluded from the previous search.

Under the Hood of Natural Language Searching

The key to processing natural language searches in dtSearch is the vector space model, which compares a natural language search request to documents with matching search terms. This model views the search request as a series of "n" dimensions in space, with "n" corresponding to the number of words in the search request. The formula looks for the smallest vector angle between the search request and other documents with matching search terms, also viewed as "n" dimensions in space. Because vector space natural language searching weighs search request terms against the density and frequency of search terms in a document collection, this feature is only available in indexed searching. (See *Indexed vs. Unindexed Searching* on the next page)

Natural Language Searching

Until now, all search requests have been structured or Boolean, with keywords such as *market*, *competitive*, *analysis*, *supermarket* and *exclusionary*, and structural connectors such as *or*, *and*, *w/25* and *not*. Boolean is great for searches involving a clear idea of what meets the terms of a search request. But what if the CIA, for example, has only a general sense of looking for some type of document match? In that case, relevancy-ranked natural language searching, also known as query-by-example, is a possible solution. Suppose the CIA operative retrieved the following block of text representing, remarkably, a terrorist limited warranty:

> any and all other representations and warranties, express or implied, including but not limited to implied warranties of merchantability, fitness for a particular purpose, including without limitation, whether *blue bird succeeds in flying over the orange house*, are expressly excluded and disclaimed.

To find a document that contains the closest match to this text—perhaps a document containing draft negotiations involving this paragraph—with natural language searching requires simply cutting and pasting this entire paragraph into a search request. Natural language searching then retrieves matching documents according to their relevancy, with the document having the highest relevancy ranking first.

The natural language search, using a query in raw format like the above paragraph, singles out keywords: *representations*, *warranties*, *express*, *implied*, etc. The search ignores connectors and other "noise" words: *any*, *and*, *all*, *other*, etc. The search then finds the documents containing the closest match to the keywords, taking into account the density and the rarity of hits.

For example, if *express* appears in 2 million documents and *warranties* appears in only two, then *warranties* would have a much higher relevancy weighting. Natural language searching is also combinable with stemming and concept searching. These options yield *warranty* and *warranties* as well as *guarantee* and *guarantees*.

Besides its status as one of the most advanced search types, natural language searching is also the easiest. For example,

Indexed vs. Unindexed Searching

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dtSearch also allows unindexed and combination indexed/unindexed searching. These search options are useful for a single pass through material to discover if there is any relevant information. For example, unindexed searching might be useful to a law enforcement agency that, after confiscating a stack of hard drives, wants to know if any data on them is pertinent to a criminal investigation. Although unindexed searching is much slower than indexed searching, it is faster to do a single unindexed search than to build a search index and then do an indexed search.

dtSearch Search Type	Indexed	Unindexed
	Speed: usually instantaneous, even across millions of documents	Speed: much slower than indexed search; but building an index and doing a single search is slower than doing an unindexed search
Concept / Synonym / Thesaurus	Yes	Yes
Fielded Data	Yes	Yes
Phrase	Yes	Yes
Boolean	Yes	Yes
Proximity and directed proximity	Yes	Yes
Wildcard	Yes	Yes
Numeric range	Yes	Yes
Macro	Yes	Yes
Stemming (finds variations on endings, like *applies*, *applied*, *applying* in a search for *apply*)	Yes	Yes
Phonic	Yes	Yes
Fuzziness (adjusts from 0 to 10 for fine-tuning fuzziness to the level of OCR or typographical errors in files—a search for *alphabet* with a fuzziness of 1 would find *alphaqet*; with a fuzziness of 3, it would find both *alphaqet* and *alpkaqet*)	Yes (fuzziness is not "hardwired" into the index, making it adjustable at the time of search)	Yes
Natural language searching, with vector-space relevancy ranking	Yes	No
Variable term weighting	Yes	Yes
Unicode	Yes	Yes

using natural language searching, a completely unstructured query—*Get me the memo by Sam Smith on the weather forecast for hurricanes in 1996*—leads right to the most relevant document.

Variable Term Weighting

Let's assume a natural language query for the confiscated paragraph comes up with millions of warranties for, of all things, birdhouses. Filtering out actual birdhouse warranties would greatly speed up the search effort. Words such as *seed* and *nest* are typical in birdhouse warranties, but are probably irrelevant to the quest for the terrorists. A search with variable term weighting could give these words a negative weight, with the resulting natural language query: *seed:-7 nest:-7 any and all other representations and warranties ....*

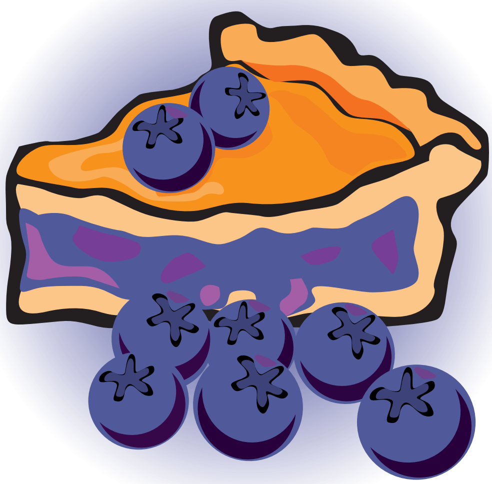
Adding the negative ratings overrides the default of having all keywords in a natural language search request rank positively by search term density and rarity. Instead, the natural language search request proceeds as before, with additional negative scoring of retrieved documents for *seed* and *nest*.

Adding greater positive weight to certain keywords further deviates from a pure natural language search request. For example, if *flying* is a key term in the paragraph, it might justify a very positive rating such as *flying:9*.

It is also possible to add variable term weights to structured or Boolean search requests. With *((market or competitive) w/25 analysis) and not supermarket*, an alternative to using *and not supermarket* to exclude all documents that contain the word *supermarket* would be to search for *((market or competitive) w/25 analysis) and supermarket:-10*. This downweights *supermarket* without excluding it entirely.

Fuzzy and Phonic Searching

And now for the missing blueberry pie recipe. After all of these complex Boolean and natural language search requests, a simple search for *blueberry* should be a piece of well ... pie. A search for *blueberry*, with stemming on, finds the entry whether it is *blueberry* or *blueberries*. But suppose *blueberry* is mispelled "*bluegerry*." Boolean searches alone could not easily come up with the correct document.



A dtSearch search for blueberry with a fuzzy level of 1 would retrieve bluegerry as well as blueberry.

The answer is fuzzy searching. Turning on search fuzziness to a low level finds words that match one or two deviations in letters: *bluegerry*, *bluugerry*, etc. Turning on fuzziness to a higher level finds words with even more deviations in letters: *blubber* and *bluster*.

Once again, there is a direct correspondence between retrieving all possible word variations and generating "false hits." For this reason, it's usually best to do the search first with a low level of fuzziness, and only if that doesn't work, to increase to a higher level of fuzziness. Note that with fuzzy searching, a misspelled search term can also find a search term that is spelled correctly in the original document.

Fuzzy searching is useful for text with spelling errors, such as typographical and OCR errors. For sound-alike errors, phonic searching can also come in handy. For example, a search for *Smith* finds *Smythe* with phonic searching.

Both fuzzy and phonic searching are combinable with Boolean, natural language and other search features. Just in case the rest of the world also can't spell, all search requests in the previous sections are combinable with fuzzy searching.

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