CS 453, Fundamentals of Information Retrieval, Spring 2016

Project Assignment 2

Suggesting Queries Based on Word Similarity and Query Modification Patterns

due Wednesday, May 25

Project Outline

This project assignment consists of implementing the *query-suggestion* approach, $WebQS$, presented in the paper, "Assisting Web Search Using Query Suggestion Based on Word Similarity Measure and Query Modification Patterns," published in the *Journal of World Wide Web*, Volume 17, Number 5, 2014. You must implement WebQS proposed in the paper to generate suggestions for a user's query.

1 Project Description

WebQS provides a guide to the users for formulating/completing a keyword query Q using suggested keywords (extracted from the AOL query logs) as potential keywords in Q. The query-suggestion approach considers *initial and modified queries* in the AOL query logs, along with *word-similarity measures*, in making query suggestions. WebQS facilitates the formulation of queries in a *trie* data structure and determines the *rankings* of suggested keyword queries using distinguished features exhibited in the raw data in the AOL query logs.

1.1 The AOL Query Logs

WebQS relies on the AOL query logs to suggest queries. The logs of AOL, which include 50 million queries that were created by millions of AOL users over a three-month period between March 1, 2006 and May 31, 2006. The query logs are made available to the class for this project assignment and posted under the CS 453 Project homepage.

An AOL query log includes a number of query sessions, each of which captures a period of sustained user activities on the search engine. Each AOL session differs in length and includes a (i) user ID, (ii) the query text, (iii) date and time of search, and (iv) optionally clicked documents. A *user ID*, which is an anonymous identifier of its user who performs the search, determines the boundary of each session (as each user ID is associated with a distinct session). *Query text* are keywords in a user query and multiple queries may be created under the same session. The *date* and *time* of a search can be used to determine whether two or more queries were created by the same user within 10 minutes, which is the time period that dictates whether two queries should be treated as *related*. *Clicked documents* are retrieved documents that the user has clicked on and are ranked by the search engine. Queries and documents include *stopwords*, which are commonly-occurring keywords, such as prepositions, articles, and pronouns, that carry little meaning and often do not represent the content of a document. Stopwords are not considered by WebQS during the query creation process.

You are supposed to implement WebQS by parsing the AOL query logs to extract query keywords while at the same time retains the information of *related* keywords in the same session, which were submitted by the same user within 10 minutes in the same session, as discussed earlier.

1.2 The Trie Data Structure

Using the extracted keywords, WebQS constructs a trie T in which each node is labeled by a *letter* in an extracted keyword in the given order, and each node in T is categorized as either "complete" or "incomplete." A *complete* node is the last node of a path in T representing an (a sequence of, respectively) extracted query keyword (keywords, respectively). If node c is a complete node, then T_c (the subtree of T rooted at a child node of c) contains other suggested keyword(s) represented by the nodes in the path(s) leading from, and excluding, c. The possible number of suggestions of a (sequence of) keyword(s) K rooted at T_c is n, where n is the number of complete nodes in subtrees rooted at T_c, and K is the (sequence of) keyword(s) extracted from the root of T_c. An *incomplete* node is the last node of a path P in T such that P does not yield a (sequence of) word(s). If c is an incomplete node, then all subsequent nodes of c up till the first complete node are potential suggestions of keywords represented by the nodes in the path leading from, and including, c.

WebQS retains the keywords in query texts in a *trie* data structure using queries in the AOL query logs. Using the trie, candidate keywords suggested for a query can be found and ranked dynamically. To suggest potential query keywords, WebQS locates a trie branch b up till the (letters in the) keywords that have been entered during the query creation process and extracts the subtrees rooted at the child nodes of the last node of b. The extracted suggestions are ranked using a set of features (presented in Section 1.3).

To simplify this assignment, you can assume that any initial query Q entered by the user is spelled correctly.

1.3 Ranking Possible Suggestions

WebQS ranks suggested query keywords in its trie data structure based on (i) the *frequency of occurrence* ($freq$) of the keywords in the AOL query logs, (ii) their *similarity* with the keywords submitted by a user based on the word-correlation factors (WCFs), and (iii) the *number of times* the keywords in user queries were *modified* (Mod) to the keywords in the suggested queries within 10 minutes as shown in the query logs. (For this project assignment, instructions will be given to you which show you how to access the word-correlation matrix.)

Given that SQ is a suggested query for a(n) (in)complete user query Q which has been entered during the query construction process, WebQS computes a *ranking* score for SQ, denoted *SuggRank* (Q, SQ), which reflects the degree of *closeness* of SQ to the letters/keywords in Q.

$$SuggRank(Q, SQ) = \frac{freq(SQ) + WCF(Q, SQ) + Mod(Q, SQ)}{1 - Min\{freq(SQ), WCF(Q, SQ), Mod(Q, SQ)\}}$$

where

- $freq(SQ)$ is the *frequency of occurrence* of SQ in the AOL query logs.
- $WCF(Q, SQ)$, which is equal to $WCF(SQ, Q)$, is as defined in Equation 1 in the paper.
- $Mod(Q, SQ)$ is the *number of times* Q is *modified* to SQ in the same session in the AOL query logs within 10 minutes.
- As $freq(SQ)$, $WCF(Q, SQ)$, and $Mod(Q, SQ)$ are in different numerical scales, prior to computing the *SuggRank* of SQ with respect to Q, they are *normalized* using a logarithmic scale to be in the same range.

For this project assignment, you are supposed to offer the top 8 suggestions, which follows the eight results displayed by major web search engines in response, to a user query.

1.4 Other Details and Guidelines

The following discussion provides further details on this project, and offers other guidelines in the design and the implementation of the project.

1. *Stopword removal.* While processing a user query Q, any leading stopwords of Q are excluded from consideration, whereas non-leading stopwords should be retained and considered for query suggestions. For example, "A" in the query "A workshop" is ignored and only "workshop" will be considered in making suggestions. (See the Stopword List of Project 1.)

2. *Making possible suggestions for a given query Q.*

   (a) Given a query Q with m (≥ 1) words, a suggested query must be of length at least $m + 1$. For example, given the query Q, "fish", a suggested query can be "fish tank". However, if Q is "tropical fish aquarium", then "tropical fish" is not a valid suggested query.

   (b) For this project assignment, you can assume that no queries will be suggested until the user has entered a correctly-spelled word, i.e., you are <u>not</u> required to make any suggestions till a completed word is entered followed by either a space, tab, or new line, which serves as the delimiter of words.

   (c) A query Q from the AOL log file is a suggested query SQ for Q, if Q has been modified to SQ within the 10-minute interval by the same user in a session. Consider the following data in an AOL user session, where XX:YY:ZZ is a time stamp:

   information 12:05:15
   information retrieval 12:05:25
   information retrieval system 12:06:01

   In this particular example, "information" is treated as Q, and "information retrieval" is a valid suggestion for Q. However, "information retrieval system" should not be considered as a modified query for Q, since it is <u>not</u> directly modified from Q. However, if the given query Q is "information retrieval", then "information retrieval system" is a valid suggestion for Q, since it is directly modified from Q in the log file.

3. $freq(SQ)$ and $mod(Q, SQ)$ in $SuggRank(Q, SQ)$. Given a query Q, the frequency of a suggested query SQ of Q, denoted $freq(SQ)$, is the *normalized* frequency of occurrence of SQ in the AOL query logs. You may choose to use any approach to normalize SQ. One of the normalization approaches is to *count* the number of times SQ appears in the query log and then *divide* it by any suggestion that appears the most in the log files. The same idea can be applied to compute the normalized frequency of occurrence of Q that has been modified to QS, i.e., $mod(Q, SQ)$.

4. $WCF(Q, SQ)$ in $SuggRank(Q, SQ)$. Given a query Q with m (≥ 1) words and a suggestion SQ with $m + i$ words, consider the last word in Q as $word_1$, and the first suggested word in SQ, i.e., the $m+1^{th}$ word in SQ as $word_2$, $WCF(word1, word2)$ is the $WCF(Q, SQ)$. For example, if Q is "tropical fish" and SQ is "tropical fish pond", $WCF($"fish", "pond"$)$ is the computed value of $WCF(Q, SQ)$. You can access the website http://peacock.cs.byu.edu/CS453Proj2/ to obtain the WCF value of two stemmed words. You are required to stem the words to extract the WCF values (see the Porter Stemmer in Project 1 for stemming). The Project homepage includes a sample java program that demonstrates how to access the link and retrieve a WCF value. For Example, http://peacock.cs.byu.edu/CS453Proj2/?word1=fish&word2=pond returns the WCF value of "fish" and "pond", which is 1.5967200397426E-6.

   A return value of -1 for two stemmed words indicates that there is no WCF value for the two words, and the WCF value of the two words should be treated *zero*. (The Java program uses Jsoup library. If you are using another programming language, you should find similar library to access the webpage.)

2 Pass-off

To receive credit for this project assignment, you must pass off your program during the TA office hours by the due date.

1. When you pass off your program, you should copy all the files (include your executable file) to the hard disk of a laptop.
2. The TA will try out different queries using different single and multiple keywords at that time, and your program is supported to create suggested queries as the TA enters a sequence of (one or more) keywords.
3. Your suggested queries for each test query Q will be compared with the targeted suggestions of Q generated by Google, Yahoo!, and Bing. Out of the top-8 suggestions created by your QS tool, your suggestions "pass" the test query Q if at least two out of the top-8 suggestions are among the combined suggestions offered by Google, Yahoo!, and Bing on Q.

The assignment is worth 150 points.