RCREZENDE BLOG

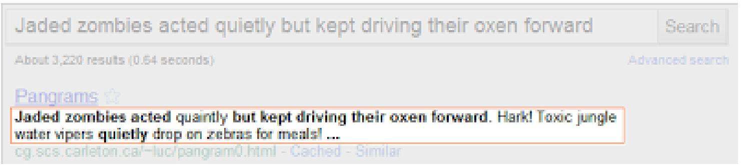
COMPUTER SCIENCE AND SOFTWARE ENGINEERING POSTS

MONDAY, AUGUST 9, 2010

The smallest relevant text snippet for search results

Like 13 people like this. Sign Up to see what your friends like.

Build a search engine it is not an easy thing to do. There are many interesting challenges that software engineers must solve in a way that millions of users must be satisfied every single day. Even the small components in a search engine must be optimized to satisfy a lot of requirements: quality, performance, accessibility and so on. For example, did you ever thought about how that small snippets of search results are built? Despite the importance of that small text to the end user, what serves as a "hint" of what is more relevant before the user click, people may ignore the clever solutions behind that snippet.


Jaded zombies acted quietly but kept driving their oxen forward Search
About 3,220 results (0.54 seconds) Advanced search
Pangrams
Jaded zombies acted quaintly but kept driving their oxen forward. Hark! Toxic jungle water vipers quietly drop on zebras for meals! ...
cg.scs.carleton.ca/~luc/pangram0.html - Cached - Similar

Example of text snippet that emphasizes the query terms

That "small" component of a search engine is executed, at least, for each result on the first page every query processed. That snippet is built from much larger texts found in webpages and you still get it all in milliseconds. That must be really fast...

This post will give you algorithms to build that snippets in a clever way, giving to the end-user a relevant part of the original text found in webpages/documents and doing that fast.

Problem Definition:

Suppose that you have two inputs: the user query and one text. Also you have one constraint: The limit of characters to show. Your task is select the most relevant parts of the original text (giving the user query terms and one constraint of the snippet length) to show to the user. "Most relevant" can be defined in different ways depending on your audience, which documents you are indexing and others things I can't imagine right now... But one thing that we can assume is that people may expect snippets that include some terms she/he used in query time. So, I'll break the problem in two parts:

- First, select the minimum text window from the original text that includes ALL query terms (I'll call that as *MINWINDOW* algorithm).
- Second, select the most relevant parts from that window, subject to the length constraint. (I'll call that as *CUT* algorithm).

Breaking that in two parts helps to abstract the concept of "most relevant" and left that to be solved further, also, it helps we use different strategies on the second part (what depends on many factors stated before). In that post I'll give you one strategy, but I'm planning a second post to give you other.

SHARE IT

SEARCH THIS BLOG

Search

ABOUT ME

RODRIGO REZENDE

VIEW MY COMPLETE PROFILE

Suppose you have a search engine API that returns a list of positions on the original text that marks where each query term has matched. For example, suppose the text below:

```
"Lorem ipsum dolor sit amet, consectetur adipiscing elit.
Cras id erat massa. Ullamcorper Lorem Sed ipsum massa risus
massa sed id Lorem, ullamcorper nec sollicitudin id, congue
sed tortor. Phasellus sed enim leo. Nullam vehicula varius
faucibus. Vestibulum augue mi, adipiscing ac sagittis ut
amet."
```

And the query: `lorem sed massa.`

Your API may return something like that:

```
token (lorem) found at positions: {0, 89, 130}
token (sed) found at positions: {95, 123, 177, 199}
token (massa) found at positions: {70, 105, 117}
```

ps.: In the final of this post you can download a simple API I designed to validate the algorithms, which is based on the inverted indices. If you want a professional API that do that and it is also free, you may consider Apache Lucene/Solr. Both Lucene and Solr have mechanisms to retrieve highlighted snippets, check it out at Solr Highlighting documentation, in special, hl.snippets and hl.fragsize. Also, If you want to get an idea of how inverted indices API can be implemented in a scalable way, you may consider this link "Batman e a Escalabilidade" (in Portuguese).

Consider the positions lists as an input of the *MINWINDOW* algorithm. In the case above:

```
List 1 = { 0, 89, 130 };
List 2 = { 95, 123, 177, 199 };
List 3 = { 70, 105, 117 }.
```

The problem can be stated as: select one element from each list so that the difference between the minimum and the maximum of the selected elements is minimized.

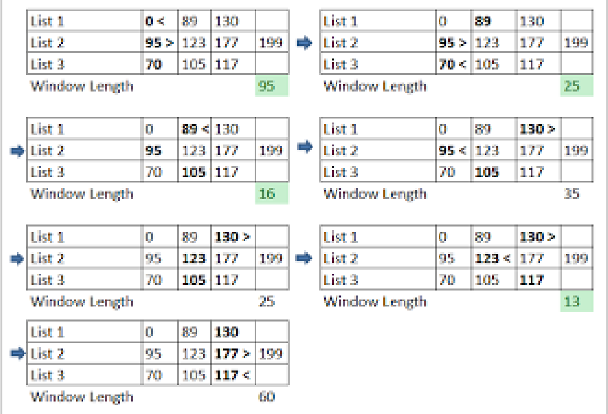
If you are not worrying about the minimization, then you may get several solutions, for instance:

1. ***"Lorem** ipsum dolor sit amet, consectetur adipiscing elit. Cras id erat **massa**. Ullamcorper Lorem **Sed".*** (At positions 0, 95 and 70)
2. ***"massa**. Ullamcorper **Lorem Sed".*** (At positions 89, 95 and 70)
3. ***"Lorem* Sed** ipsum **massa".** (At positions 89, 95 and 105)
4. **"massa sed** id **Lorem".** (At positions 130, 123 and 117)

The fourth snippet is the minimum window that includes all query terms, so the solution of *MINWINDOW* algorithm.

Now, I think we can start design the algorithm: One quick and dirty algorithm is the brute force one. In other words, verify all combinations. Of course that works, but you don't want that! If you have a constant number of terms in the query, this algorithm is polynomial on the average length of lists. Although most of search engines limits the number of tokens in query, say K, this is still impracticable: O(avg^k). But this algorithm can be still useful as an Oracle for your unit tests.

window length, you must change one element selected from any of the lists in a way that you increase the current minimum element or decrease the maximum element selected so far. If the lists are sorted (ascendent), you can't decrease the maximum element, then the only choice you have is try to increase the minimum. If you can't increase the minimum then the current best solution cannot be improved and the algorithm finishes. The current minimum can be selected using a minimum heap, which gives the log(K) factor - O(1) to select and O(log(K)) to update the datastructure. The figure below shows the algorithms steps:



List 1	**0 <**	89	130	
List 2	**95 >**	123	177	199
List 3	**70**	105	117	
Window Length				95

List 1	0	**89**	130	
List 2	**95 >**	123	177	199
List 3	**70 <**	105	117	
Window Length				25

List 1	0	**89 <**	130	
List 2	**95**	123	177	199
List 3	70	**105**	117	
Window Length				16

List 1	0	89	**130 >**	
List 2	**95 <**	123	177	199
List 3	70	**105**	117	
Window Length				35

List 1	0	89	**130 >**	
List 2	95	**123**	177	199
List 3	70	**105**	117	
Window Length				25

List 1	0	89	**130 >**	
List 2	95	**123 <**	177	199
List 3	70	105	**117**	
Window Length				13

List 1	0	89	**130**	
List 2	95	123	**177 >**	199
List 3	70	105	**117 <**	
Window Length				60

Example of the algorithm execution.

Here you have a Java implementation of the algorithm described above, but instead using a heap it's implemented a linear search to find the current minimum, so the final complexity is O(avg(list length) * K^2) :

```java
//to avoid special cases, it is assumed that
//the last element of each list is the Integer.MAX_VALUE
//the algorithm returns the position of each term of
//the minimum window
static int[] solve(int[][] lists) {
 int m = lists.length;
 //the current selected element from each list
 int[] pos = new int[m];
 //the current best solution positions
 int[] sol = new int[m];
 //the score (window length) of current solution
 int currSol = Integer.MAX_VALUE;
 while(true) {
  //select the list that has the increasing minimum element
  int minList = argmin(pos,lists);
  //if you can't increase the minimum, stop
  if (minList == -1) break;
  //calculate the window size
  int minValue = lists[minList][pos[minList]];
  int maxValue = max(pos,lists);
  int nextSol = maxValue - minValue;
  //update the solution if necessary
  if(nextSol < currSol ) {
   currSol = nextSol;
   System.arraycopy(pos, 0, sol, 0, m);
  }
  //update the current minumum element
  pos[minList]++;
 }
 return sol;
}
private static int argmin(int[] pos, int[][] v) {
 int min = Integer.MAX_VALUE;
 int arg = -1;
 for(int i = 0 ; i < v.length; ++i) {
  if(v[i][pos[i]] < min) {
   min = v[i][pos[i]];
   arg = i;
  }
  int arg = -1;
  for(int i = 0 ; i < v.length; ++i) {
   if(v[i][pos[i]] > max) {
    max = v[i][pos[i]];
    arg = i;
   }
  }
  return arg;
 }
 private static int max(int[] pos, int[][] v) {
  int arg = argmax(pos, v);
  return v[arg][pos[arg]];
 }
```

The CUT Algorithm

After running the *MINWINDOW* algorithm you obtain the smallest window text that contains all query terms. But that window can be still larger than what you want to show to the users. In that case, you must cut the smallest window. A valid strategy is cut that window in several positions, giving to the end-user a sequence of fragments which keep as much queried terms as possible. It looks like the majors search engines do that... I'll left that strategy, referred here as *FRAGMENTCUT* algorithm, to the next post. Now, I'll try a different approach: Cut only the edges.

The EDGECUT Algorithm

The idea of this algorithm is cut words from the edges to preserve the text flow. The heuristic is that users may like that because they can understand better the snippet compared to the *FRAGMENTCUT* strategy.

There are several different cuts on the edges that produces snippets that fits the length constraint. So, what is the best one? One may prefer the cut that keep the maximum number of terms, other may prefer the cut that preserves the query terms that maximize the tf-idf. To abstract that, suppose you have an objective function F that encodes what you prefer. In that case, let's design an efficient algorithm:

First, the number of all edge cuts is O(M^2), where M is the number of terms in the query. So the bruteforce algorithm is O(M^2). If we consider M a constant, which is true in many search engines, that algorithm is O(1). But I'll ignore that and show that *EDGECUT* can be done in O(M + M*log(M)).

For this algorithm consider as input a list of positions of terms matched selected by the *MINWINDOW* algorithm. Also, the length of each term. Using the previous example:

```
positions = {130,123,117}
lengths = {5 "loren", 3 "sed", 5 "massa"}
```

First sort that list of positions (keep track of the lengths). Next it's very simple, you just need evaluate the objective function in every window size equals the constraint length. You start moving that window from the first position to the last one.

Java implementation of *EDGECUT* algorithm

```
//max: the constraint of snippet length
//pos: the positions of each term and lengths
//returns: the firt and last position
public static int[] cut(TokenInfo[] pos, int max) {
 int n = pos.length;
 //sort the positions
 Arrays.sort(pos);
 //start the window at the first position
 for(int start = 0; start < n; start++) {
  //discover the end of the window
  for(int nextend = end; nextend < n ; nextend++) {
   int len = pos[nextend].offset - pos[start].offset + pos[nexter
   if(len > max) break;
   end = nextend;
  }
  //evaluate the objective function and update the best solution
  double nextSol = objectiveFunction(pos, start, end);
  if(nextSol > currSol) {
   solStart = start;
   solEnd = end;
   currSol = nextSol;
  }
 }
 return new int[]{solStart, solEnd};
}
public static double objectiveFunction(TokenInfo[] pos, int star
 //the objective function is the number of query terms included
 return end-start+1;
}
```

You can download all sourcecode here. This file includes the algorithms described here plus simple tokenization, inverted indice search and text terms emphasize algorithm.

Like 13 people like this. Sign Up to see what your friends like.

POSTED BY RODRIGO REZENDE AT 2:57 AM

Home Older Post

Subscribe to: Post Comments (Atom)