Question answering system for the French language

Laura Perret
Institut interfacultaire d'informatique
University of Neuchâtel, Pierre-à-Mazel 7, 2000 Neuchâtel, Switzerland
Laura.Perret@unine.ch
http://www.unine.ch/info/clef/

Abstract

This paper describes our first participation in the QA@CLEF monolingual and bilingual task, where our objective was to propose a question answering system designed to respond to French queries submitted to search French documents. We wanted to combine a classic information retrieval model (based on the Okapi probabilistic model) with a linguistic approach based mainly on syntactic analysis. In order to utilize our monolingual system in the bilingual task, we automatically translated into French queries written in seven other source languages, namely Dutch, German, Italian, Portuguese, Spanish, English and Bulgarian.

Introduction

For the first time QA@CLEF-2004 has proposed a question-answering track that allows various European languages to be used either as a source or target language. Our aim in this study was to develop a question answering system for the French language and to evaluate its performance. In Section 1, we describe how we developed our question answering system to carry out the monolingual French task. As a first step in this process, we applied a classical information retrieval model (based on the Okapi probabilistic model) to extract a small number of responding paragraphs for each query. We then analyzed the queries and sentences included in retrieved paragraphs using a syntactic analyzer (FIPS) developed at the Laboratoire d'analyse et de Technologie du Langage (LATL) at the University of Geneva. Finally, we suggested a matching strategy that would extract responses from the best-ranked sentences. In Section 2, we describe methods used to overcome language barriers by accessing various translation resources to translate various queries into French and then, with French as target language, utilize our question answering system to carry out this bilingual task. In Section 3, we discuss the results obtained from this technique and in the last section we draw conclusions on what improvements we might envisage for our system.

1. Monolingual Question Answering

The monolingual task was designed for six different languages, namely Dutch, French, German, Italian, Portuguese, and Spanish. Given that our question answering system is language dependant, we only addressed the French monolingual task.

1.1 Overview of the Test-Collection

Given that we did not have previous experience in building a QA system, we developed a test set consisting of 57 homemade factual queries from corpora consisting of the newspapers *Le Monde* (1994, 157 MB) and *SDA French* (1994, 86 MB). Table 1 shows some examples of these queries.

Query	Answer string	Supporting document
Où se trouve le siège de l'OCDE ?	Paris	LEMONDE94-000001-19941201
Qui est le premier ministre canadien ?	Jean Chrétien	LEMONDE94-000034-19941201
Combien de collaborateurs emploie ABB ?	206 000	ATS.941214.0105

Table 1. Examples of factoid test queries

1.2 Information Retrieval Scheme

Firstly, we split the test collection into paragraphs using the <TEXT> tag as delimiter for *Le Monde* documents and the <TX> tag as delimiter for the *SDA French* documents.

For each paragraph, we then removed the most frequent words, using the French stopword list available at www.unine.ch/info/clef/. From this stopword list we removed numeral adjectives such as « premier » (first), « dix-huit » (eighteen), « soixante » (sixty), assuming that answers to factoid questions may contain numerical data. The final stopword list contained 421 entries.

After removing high frequency words, we also used an indexing procedure as a stemming algorithm (also available at www.unine.ch/info/clef/ [1]). We assumed that looking for exact answers requires a lighter stemmer, one that would not affect the part-of-speech categorization for terms. Our stemmer thus only removed inflectional suffixes so that singular and plural, and also feminine and masculine forms, would conflate to the same root. Table 2 describes our stemming algorithm.

if word length greater than 5	
if word ends with « aux » then replace « aux » by « al »	chevaux -> cheval
else	
if word ends with ‘s’ then remove ‘s’	chats -> chat
if word ends with ‘r’ then remove ‘r’	chanter -> chante
if word ends with ‘e’ then remove ‘e’	chatte -> chatt
if word ends with ‘é’ then remove ‘é’	chanté -> chant
if word ends with a double letter then remove the last letter	chatt -> chat

Table 2. Stemming algorithm

For our indexing and search system, we used a classical SMART information retrieval system [4] to retrieve the ten best paragraphs for each query from the underlying collection. In our experiment, we chose the Okapi probabilistic model (BM25), setting our constants to the following values: b=0.8, k_1=2 and $avdl$=400.

1.3 French Syntactic Analysis

In a second step, we used the French Interactive Parsing System (FIPS), a robust French syntactic analyzer developed at the LATL in Geneva [5], [6], [7]. This tool is based on the Chomsky’s Theory of Principles and Parameters [8] and the Government and Binding model [9], [10]. It takes a text as input, splits it into sentences, and then for each sentence computes a syntactic structure.

We took advantage of this tool to analyze the queries as well as the paragraphs retrieved by our classical IR system. Table 3 shows the analysis obtained for the Query #1 « Quel est le directeur général de FIAT ? » (Who is the managing director of FIAT?)

Term	POS	Concept number	Named entities	Lexeme number	Lemma
quel	PRO-INT-SIN-MAS	211049516		0	quel
est	VER-IND-PRE-SIN	211000095 211021507 211048855 211049530		4	être
le	DET-SIN-MAS	211045001		8	le
directeur	NOM-SIN-MAS	211014688	{0, 13, 24}	11	directeur
général	ADJ-SIN-MAS	211014010		21	général
de	PRE	211047305		29	de
FIAT	NOM-SIN-ING	0	{16}	32	FIAT
?	PONC-interrogation	0		37	?
[CP[DP quel]i[C [TP[DP ei][T est [VP [DP le [NP directeur [AP[DP ej][A général [PP de [DP FIAT]]]]]j]]]] ?]]					

Table 3. Example of FIPS analysis

The last row in Table 3 showes a syntactic analysis of the complete sentence while the other rows show items of information on each word in the sentence. For each word, the first column contains the original term, the second column the part-of-speech and the third the concept number. The forth column lists the named entities, the fifth the lexeme number while the last column shows the lemma used as the dictionary entry.

The original tool was adapted in order to provide two sorts of named entities recognition: numeral named entities (Table 4) and noun named entities (Table 5).

Named entity	Example
numeral	premier (first)
percent	23%
ordinal	1er
special number	751.04.09
cardinal	1291
digit	12, douze (twelve)

Table 4. All numeral named entities recognized by FIPS

Named entity	Example	Named entity	Example
human	homme (man)	action	grève (strike)
animate	chat (cat)	collective	équipe (team)
quantity	kilo (kilo)	country	Switzerland
time	heure (hour)	town	Paris
day	lundi (Monday)	river	Gange
month	mai (Mai)	mountain	Everest
weight	gramme (gram)	people	John
length	mètre (meter)	proper name	Yangze
location	bureau (office)	corporation	IBM
abstraction	liberté (freedom)	title	Monsieur (Mister)
physical object	livre (book)	function	président (president)

Table 5. All noun named entities recognized by FIPS

From a collection of all available information from FIPS, we built a tree structure to represent the syntactic analysis of each query and sentence that would then be used for the rest of the process.

1.4 Matching Strategy

Once we had the queries and the best responding paragraphs analyzed by FIPS, we developed a matching scheme, one that allowed our system to find the best answer snippet.

Query Analysis

We analyzed the queries in order to determine their relevant terms, targets and expected answer types. To facilitate the retrieval of a response, we selected the relevant terms from a query. A term was considered relevant if its *idf* was greater than 3.5 ($idf = \ln(n / df)$, where n denotes the number of documents in the collection and df the number of documents that contain the term). This threshold was chosen empirically according to our collection size (730,098 paragraphs) and corresponds to a df of about 20,000.

We then looked within the query for an interrogative word. As our syntactic analyzer was able to supply the lemma for any known term (last column of Table 3), our interrogative words set was reduced to the following list {quel, qui, que, quoi, où, quand, combien, pourquoi, comment}. Most queries contain an interrogative word from this list except queries such as « Donnez le nom d'un liquide inodore et insipide. » (Name an odourless and tasteless liquid.).

We defined the query target by choosing the first term after the interrogative word, whose part-of-speech tag was labelled by FIPS as NOM-* (noun). If the query did not contain an interrogative word, the target was searched from the beginning of the query. Some particular words were however excluded from the allowed targets since they did not represent relevant information. The list of excluded targets was:

nombre, quantité, grandeur, dimension, date, jour, mois, année, an, époque, période, nom, surnom, titre, lieu

As illustrated in Table 6, using the query interrogative word and target, we categorized queries under six classes.

Class	Interrogative words	Specific target	Example
Class 1	quel, quoi, comment, pourquoi, que, qu'est-ce que	-	Comment appelle-t-on l'intérieur d'un bâteau ? Qu'a inventé le baron Marcel Bich ?
Class 2	où	-	Où se trouve le siège de l'OCDE ?
Class 3	combien quel + numeral target none + numeral target	numeral target: pourcentage, nombre, quantité, distance, poids, longueur, hauteur, largeur, âge, grandeur, dimension, superficie	Combien de membres compte l'OCDE ? A quel âge est mort Massimo Troisi ?
Class 4	quand, quel + time target none + time target	time target date, jour, mois, année, an, époque, période	Quand est né Albert Einstein ? En quelle année est né Alberto Giacometti ?
Class 5	qui, quel + function target none + function target	function target président, directeur, ministre, juge, sénateur, acteur, chanteur, artiste, présentateur, réalisateur	Qui est Jacques Chirac ? Quel est le président du parti socialiste suisse ?
Class 6	-	-	Donnez le nom d'un liquide inodore et insipide.

Table 6. Query classes

Once we classified the queries into their corresponding classes, we identified the expected answer type for each class. Their order has no influence on the system. Table 7 shows the details of these classes.

Class	Expected answer type
Class 1	all noun named entities
Class 2	location, country, town, river, mountain, proper name
Class 3	quantity, weight, length and all numeral named entities
Class 4	time, day, month, numeral, ordinal, special number, cardinal, digit
Class 5	human, animate, collective, people, corporation, title, function, proper name
Class 6	all noun named entities

Table 7. Expected answer type per query class

Sentences Ranking

Given that the analyzer split the paragraphs into sentences, we ranked the sentences according to the score computed by the Formula 1 where *sentenceRelevant* is the number of relevant query terms in the sentence, *sentenceLen* is the number of terms in the sentence and *queryRelevant* is the number of relevant terms in the query (without stopwords):

$$score = sentenceRelevant * sentenceLen / (sentenceLen - queryRelevant) \quad (1)$$

We then chose the ten sentences having the highest score. Table 8 shows the four best selected sentences for Query #19 « Où se trouve la mosquée Al Aqsa ? » (Where is the Al Aqsa Mosque?).

Rank	Score	Document and sentence
1	2.148	[ATS.950417.0033] : la police interdit aux juifs de prier sur l' esplanade où se trouve la mosquée al-Aqsa , troisième lieu saint de l' islam après la Mecque et Médine .
2	2.102	[ATS.940304.0093] : la police a expliqué qu' elle bouclait le site le plus sacré du judaïsme jusqu' à la fin de la prière du vendredi à la mosquée Al -- Aqsa , laquelle se trouve sur l' Esplanade du Temple qui domine le Mur des Lamentations .
3	1.4	[ATS.940405.0112] : la mosquée al Aqsa rouverte aux touristes .
4	1.117	[ATS.940606.0081] : cette phrase laisse ouverte la possibilité pour M. Arafat d' aller prier à la mosquée al-Aqsa à Jérusalem .

Table 8. Best sentences selected for Query #19

Snippets Extraction

For each selected sentence, we searched the identified query target. If the target was never found, we selected the first sentence for the rest of the process. We then listed the terms of the expected answer types in a window containing the 4 terms before and after the target term. *Confidence* in this sentence was computed according to Formula 2 where *score* was the initial score of the sentence and *maxScore* the score of the best-ranked sentence for the current query. If the *maxScore* was equal to zero, the sentence score was also set to zero.

$$confidence = score / maxScore \quad (2)$$

For each expected type term found, we extracted the closest DP (determiner-phrase) or NP (noun-phrase) group node from the sentence analysis tree. Thus, each sentence may produce one or more nodes (as shown in Table 9, 2nd and 3rd row). From the list obtained in the previous step, we then eliminated all nodes contained in other nodes whose difference level was less than 7. The level represents the node depth in the syntactic analysis tree.

We then pruned the remaining nodes by extracting the part of the node that did not contain query term. Finally, following the pruning process, we eliminated any snippets that did not contain expected answer terms. For Query #19 where the correct answer is “Jérusalem”, Table 9 lists the remaining nodes.

Document	Confidence	Answer candidate
ATS.940304.0093	0.978	Al -- Aqsa
ATS.940606.0081	0.520	M. Arafat
ATS.940606.0081	0.520	Jérusalem
LEMONDE94-001632-19940514	0.509	Jérusalem
ATS.941107.0105	0.507	Jérusalem
ATS.940304.0093	0.496	Ville
ATS.940304.0093	0.496	Al-Aqsa l'un des lieux saints de l' islam
LEMONDE94-001740-19940820	0.494	le Saint-Sépulcre
ATS.940405.0112	0.494	le Waqf
ATS.951223.0020	0.492	à Jérusalem
ATS.951223.0020	0.492	Bethléem

Table 9. Remaining nodes for Query #19

Voting Procedure

We supposed that an answer having a lower confidence than the best candidate could nevertheless be a good answer if it was supported by more documents. Therefore, the last step of the process was to choose which remaining snippet should be returned as the response by implementing it with the voting procedure.

First we split each snippet into words, and then we counted the occurrences of each non-stopword in other snippets. Finally, we ranked the snippets according to their scores computed using Formula 3 where *len* was equals to *1* for definition queries and the *snippet words count* for factoid queries. Indeed, as definition responses may be longer than factoid responses, we did not want to penalize long definition responses.

score = occurrencesCount / len (3)

If the *occurrencesCount* was equal to zero, we chose the first snippet but decreased its confidence. Else, we chose the snippet with the higher score as answer. Table 10 shows the snipped chosen for Query #19.

Document	Confidence	Answer candidate
ATS.940606.0081	0.520	Jérusalem

Table 10. Snippet chosen for Query #19

2. Bilingual Question Answering

Given that our question answering system was developed for the French language, we only addressed bilingual tasks in which French was the target language. We therefore submitted results for Dutch, German, Italian, Portuguese, Spanish, English and Bulgarian as source languages, with French as the target language.

2.1 Automatic Query Translation

Since our QA system was designed to respond to French queries concerning French documents, we needed to translate original the queries formulated in other languages into French. In order to overcome language barriers, we based our approach on free and readily available translation resources that would automatically translate queries into the desired target language, namely French [2], [3]. These resources were:

1. Reverso (www.reverso.fr)
2. TranslationExperts.com (intertran.tranexp.com)
3. Free2Professional Translation (www.freetranslation.com)
4. AltaVista (babelfish.altavista.com)
5. Systran™ (www.systranlinks.com)
6. Google.com™ (www.google.com/language_tools)
7. WorldLingo™ (www.worldlingo.com)

Table 11 shows the languages supported by each translation resource when the target language is French, with the best resource for each language being marked with a star (*). Since the Bulgarian language uses the Cyrillic alphabet, we added a specific step to transliterate non-translated words using the table available at www.world-gazetteer.com/pronun.htm#cyr.

	Source language						
Translation resource	**bg**	**de**	**en**	**es**	**it**	**nl**	**pt**
Reverso		√ *	√ *	√ *			
TranslationExperts.com	√ *	√	√	√	√	√	√
Free2Professional Translation			√				
AltaVista		√	√	√	√	√	√
Systran™		√	√	√	√	√	√
Google.com™		√	√				
WorldLingo™		√	√	√	√ *	√ *	√ *

Table 11. Available translation resources with French as target

2.2 Translation Examples

Table 12 shows the translations obtained for the original French Query #1 « Quel est le directeur général de FIAT ? » (Who is the managing director of FIAT?).

Source language	Original query	Translated query
Bulgarian	Кой е управителният директор на ФИАТ?	Qui å upravitelniiat direktor na FIAT?
German	Wer ist der Geschäftsführer von FIAT?	Qui est le directeur de FIAT ?
English	Who is the managing director of FIAT?	Qui est le directeur général de DéCRET ?
Spanish	¿Quién es el director gerente de FIAT?	Qui est-ce qui est le directeur gérant de CONSENTEMENT ?
Italian	Chi è l'amministratore delegato della Fiat?	Qui est le directeur exécutif général de Fiat ?
Dutch	Wie is de bestuursvoorzitter van Fiat?	Qui est-il le président d'administration de fiat ?
Portuguese	Quem é o administrador-delegado da Fiat?	Qui est l'agent d'administrateur-commission de Fiat ?

Table 12. French translations of Query #1

3. Results

Each answer was assessed and marked as correct, inexact, unsupported or wrong, as illustrated in the following examples. An answer was judged correct by a human assessor when the answer string consisted exactly of the correct expected answer and this answer was supported by the returned document. For example, the pair ["Cesare Romiti", ATS.940531.0063] was judged correct for the Query #1 « Quel est le directeur général de FIAT ? » (Who is the managing director of FIAT?), since the supporting document contained the string « directeur général de Fiat Cesare Romiti ». Secondly, an answer was judged inexact when the answer string contained more or less than just the correct answer and the answer was supported by the returned document. For example, the pair ["premier ministre irlandais", ATS.940918.0057] was judged inexact for the Query #177 « Quelle est la fonction d'Albert Reynolds en Irlande ? » (What office does Albert Reynolds hold in Ireland?), since the adjective « irlandais » was redundant. Thirdly, an answer was judged unsupported when the returned document didn't support the answer string. Since our system only searched within collection documents provided, none of our answers was judged unsupported. Finally, an answer was judged wrong when the answer-string was not a correct answer. For example, the pair ["Underground", ATS.950528.0053] was judged wrong for the Query #118 « Qui a remporté la palme d'or à Cannes en 1995 ? » (Who won the Cannes Film Festival in 1995?), since « Underground » is the movie title whereas « Emir Kusturica » is the movie director and was the expected answer. Table 13 shows the results obtained for each source language. Given that the target language was French, logically the best score was obtained in the monolingual task where no translation was needed.

	Monolingual	Bilingual						
Source language	**fr**	**de**	**es**	**nl**	**it**	**pt**	**en**	**bg**
Right	49	34	34	29	29	29	27	13
Inexact	6	12	4	15	7	7	9	7
Unsupported	0	0	0	0	0	0	0	0
Wrong	145	154	162	156	164	164	164	180
Accuracy	24.5%	17.0%	17.0%	14.5%	14.5%	14.5%	13.5%	6.5%
Nil correct	9.1%	23.5%	11.8%	14.8%	14.3%	10.0%	6.7%	10.1%
Translation cost		-30.6%	-30.6%	-40.8%	-40.8%	-40.8%	-44.9%	-73.5%

Table 13. Results

We can see that the translation process resulted in an important performance decrease compared to the monolingual French experiment (up to 73.5% for Bulgarian). It was surprising to note that the English translation was listed as having the next to worst performance, just before the Bulgarian Cyrillic alphabet language. However, a deeper analysis showed that in 7.5% (15/200) of cases, a majority of the various source languages translations (> 4) provided a correct answer whereas in 2.5% (5/200) of cases, they agreed on inexact answers. This might suggest that the translation did not have much affect on the system's ability to find a correct or inexact answer for about 10% of the queries.

Looking at the answers marked as wrong in more detail, we detected some possible causes in addition to the translation problem. First of all, for some queries, we could not retrieve any corresponding document from the collection. Sometimes, we chose the wrong target and/or expected answer type. Thirdly, we were not able to account for the time reference, as in Query #22 « Combien a coûté la construction du Tunnel sous la Manche ? » (How much did the Channel Tunnel cost?) for which we provided the answer ["28,4 milliards de francs", LEMONDE94-002679-19940621] supported by the sentence "à l'origine, la construction du tunnel devait coûter 28,4 milliards de francs". In this case, our answer gave the initial estimate but not the final cost.

Conclusion

For our first participation in the QA@CLEF track, we proposed a question answering system designed to search French documents in response to French queries. To do so we used a French syntactic analyzer and a named entities recognition technique in order to assist in identifying the expected answers. We then proposed a matching strategy based on the node extraction from the analysis tree, followed by a ranking process.

In our bilingual task we used automatic translation resources to translate the original queries from Dutch, German, Italian, Portuguese, Spanish, English and Bulgarian into French. The remainder of this process was the same as that used in the monolingual task.

The results showed performance levels of 24.5% for the monolingual task and up to 17% (German) for the bilingual task. There are several reasons for these results, among them being the selection process for the target and expected answer types. In the bilingual task, we verified that, as expected, the translation step was a significant factor in performance level losses, given that for German the performance level had decreased by about 30%.

Our system could be improved by using more in-depth syntactic analyses for both queries and paragraphs. Also, the target identification and queries taxonomy could be extended in order to obtain a more precise expected answer type.

Acknowledgments

The author would like to thank Eric Wehrli, Luka Nerima and Violeta Seretan from LATL (University of Geneva) for supplying the FIPS French syntactic analyzer as well as the task CLEF-2004 organizers for their efforts in developing various European languages test-collections. The author would also like to thank C. Buckley from SabIR for giving us the opportunity to use the SMART system. Furthermore, the author would like to thank J. Savoy for his advice on the preliminary version of this article as well as Pierre-Yves Berger for his contributions in the area of automatic translation. This research was supported in part by the SNSF (Swiss National Science Foundation) under grant 21-66 742.01.

References

[1] Savoy J., A stemming procedure and stopword list for general French corpora., Journal of the American Society for Information Science, 1999, 50 (10), p. 944-952.

[2] Savoy, J., Report on CLEF-2003 multilingual tracks, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 7-12.

[3] Savoy J., Combining multiple strategies for effective cross-language retrieval. In: Information Retrieval, 2004, 7(1-2), p. 121-148.

[4] Salton G., The Smart Retrieval System Experiments in automatic document processing, Prentice-Hall, Englewood Cliffs, 1971.

[5] Laenzlinger C., Wehrli E., FIPS : Un analyseur interctif pour le français, In: TA Informations, 1991, 32(2), p. 35-49.

[6] Wehrli E., Un modèle multilingue d'analyse syntaxique, In: A. Auchlin, M. Burer, L. Filliettaz, A. Grobet, J. Moeschler, L. Perrin, C. Rossari et L. de Saussure, Structures et discours -- Mélanges offerts à Eddy Roulet, 2004, Québec, Editions, Nota bene, p. 311-329.

[7] Wehrli E., L'analyse syntaxique des langues naturelles : Problèmes et méthodes, 1997, Paris, Masson.

[8] Chomsky N., Lasnik H., The theory of principles and parameters, In: Chomsky N., (1995) The Minimalist Program. Cambridge, MIT Press, pp. 13-127.

[9] Chomsky N., The Minimalist Program, 1995, Mass., MIT Press.

[10] Haegeman L., Introduction to government and binding theory, 1994, Oxford, Basil Blackwell.

[11] Magnini B., Romagnoli S., Vallin A., Herrera J., Peñas A., Peinado V., Verdejo F., de Rijke M., The multiple language question answering track at CLEF 2003, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 299-310.

[12] Negri M., Tanev H., Magnini B., Bridging languages for question answering: DIOGENE at CLEF 2003, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 321-329.

[13] Echihabi A., Oard D., Marcu D., Hermjakob U., Cross-Language question answering at the USC Information Sciences Institute, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 331-337.

[14] Jijkoun V., Mishne G., de Rijke M., The University of Amsterdam at QA@CLEF2003, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 339-342.

[15] Plamondon L., Foster G., Quantum, a French/English cross-language question answering system, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 355-362.

[16] Neumann G., Sacaleanu B., A Cross-language question/answering-system for German and English, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 363-372.

[17] Sutcliffe R., Gabbay I., O'Gorman A., Cross-language French-English question answering using the DLT System at CLEF 2003, In: Proceedings of CLEF 2003, Trondheim, 2003, p. 373-378.

[18] Voorhees E. M., Overview of the TREC 2003 question answering track, In: Notebook of the Twelfth Text REtrieval Conference (TREC 2003), Gaithersburg, 18-21 November 2003, p. 14-27.

[19] Harabagiu S., Moldovan D., Clark C., Bowden M., Williams J., Bensley J., Answer mining by combining extraction techniques with abductive reasoning, In: Notebook of the Twelfth Text REtrieval Conference (TREC 2003), Gaithersburg, 18-21 November 2003, p. 46-53.

[20] Voorhees E. M., Overview of the TREC 2002 question answering track, In: Voorhees E.M., Buckland L.P. (Eds.): Proceedings of the Eleventh Text REtrieval Conference (TREC 2002), Gaithersburg, 19-22 November 2002, p. 115-123.

[21] Soubbotin M., Soubbotin S., Use of patterns for detection of likely answer strings: A systematic approach, In: Voorhees E.M., Buckland L.P. (Eds.): Proceedings of the Eleventh Text REtrieval Conference (TREC 2002), Gaithersburg, 19-22 November 2002, p. 325-331.