Question Answering System using Concept-based Vector Space Model

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Abstract

This paper presents the architecture of the Concept-based Vector Space Model Question Answering System (CBVSM-QAS) developed at the Nagaoka University of Technology (NUT) and used in the 4-th NTCIR workshop Question Answering Challenge (QAC) evaluation. The CBVSM-QAS runs on the factual question, which is, correspond to the subtask-1 in the NTCIR-4's QAC. One major peculiarity of this system is the idea of placing the whole data set in the concept-based vector space, and the searching of the answer for each question is done by the calculating the nearest newspapers documents' vector. In this paper, the architecture of the system used during the formal run of NTCIR-4's QAC and the architecture of the system after some improvement is introduced.

Keywords: Concept-based, Vector space, NTCIR

1. Introduction

Our team, NUT, based in Nagaoka University of Technology's knowledge system laboratory, challenges to study on the peculiarity of concept-based model and its potential in the information retrieval. The reason of why we focused on this concept-based model is that the model is theoretically able to retrieve the information despite the incompleteness of the query words. As for the presently used information retrieval algorithm such as Boolean model, only the document which is containing all of the query words will be retrieved (in case of the query expression is composed using AND operator). This means that within all of the query words, even one word is not contained in the document, the document will be removed from the candidate of retrieval. These will probably results some important document dropped out during the information retrieval. Concerning this problem, we are attracted by the potential of concept-based model. In the concept-based model, information retrieval are executed by comparing the query characteristic to document characteristic that is even some words in the query words are not contained in a particular document, the document is still judged as one of the candidate answer.

In this paper, implementation of the concept-based vector space as the main algorithm for the question answering system is proposed.

2. The generation of concept-based vector space.

The concept-based information retrieval model is one of the variations of the vector space model. To put it simply, the concept-based model is knowledge-based of the words contained in the document set, which vectors are assign to each words. In the concept-based vector space model, each target documents are characterized by the appearance frequency of each word contained in a particular document. These means that the concept-based contains are differs for different document collections. Document vector is generated by the composition of the words' vector contained in the document. Using this document vector and the vector of the question word, the cosine's coefficient is calculated and ranks the entire target document. In this IR model, the document with the larger cosine's coefficient should be the document which is most related to the question word, as the document poses the nearest location to the question word in the vector space comparing to other documents. These explains the merit of the concept-based model as even some words in the query vector are not contained in the particular document, as long as the cosine coefficient are the biggest, the document is the best candidate answer.

In concept-based model, as the words vector are generated using the target documents, the words' co-occurrences in the target documents are statistically calculated. In details, for N words (N=1,000~10,000), which is the word with high frequency contained in the target documents, a neighborly co-occurrence matrix (N×N) of the words are generated. (Refer to table1). Due to the limit of the amount of computing resources, the words contained in the concept-based are limited to 10,000 words. The words are chosen with the priority to the words with high co-occurrences frequency. The words with lower co-occurrences frequency in the entire document collection will have more probability of dropped out from the concept-base.

	Word A	Word B	Word C	…
Word A	0	0	1	
Word B	0	0	0	
Word C	2	0	0	
⋮				

Table1: generation of the N×N Matrix

This matrix then, compressed to 100~200 dimension by implementation of Singular Value Decomposition (SVD), and finally generating the concept base (Refer to table2).

	c_1	c_2	c_3	…
Word A	c_{11}	c_{21}	c_{31}	
Word B	c_{12}	c_{22}	c_{32}	
Word C	c_{13}	c_{23}	c_{33}	
⋮				

Table2: compression of N×N Matrix by SVD (concept base)

Document vector, which representing the concept (words) included in the particular document, is generated by the composition of the concept's vector within it. The question vector, similarly, is generated by the composition of each concept contained in the questions, a short sentence composed from some words.

Retrieval process is done by calculating the similarity degree of the question sentence's vector and the each document's vector. The target document then, sorted up by the degree of their similarity against the question sentence for the most related document should be the document with highest similarity degree.

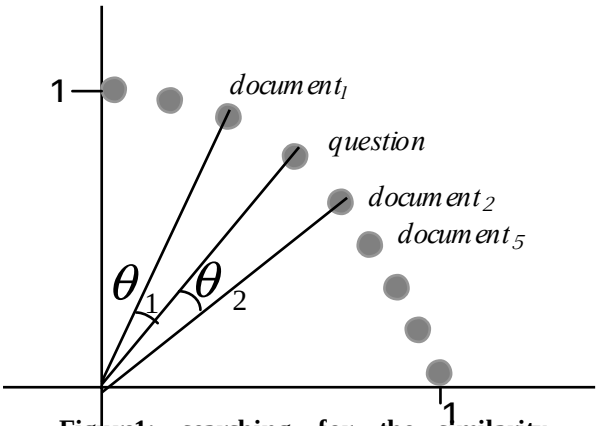

Figure1: searching for the similarity degree of the question and the document collections.

3. The architecture of the CBVSM-QAS

The NTCIR-4's QAC was the first attempt for NUT team's to design the question and answering system. By that reason, many defects were created within the progress. NUT's attempt to implement the CBVSM into the question answering system continues but by the reason of time limit of the NTCIR-4's QAC2 formal run, we will explain the architecture of the CBVSM-QAS on the first stage (that used for the QAC2 formal run), and the improved system (created after the QAC2 formal run deadline).

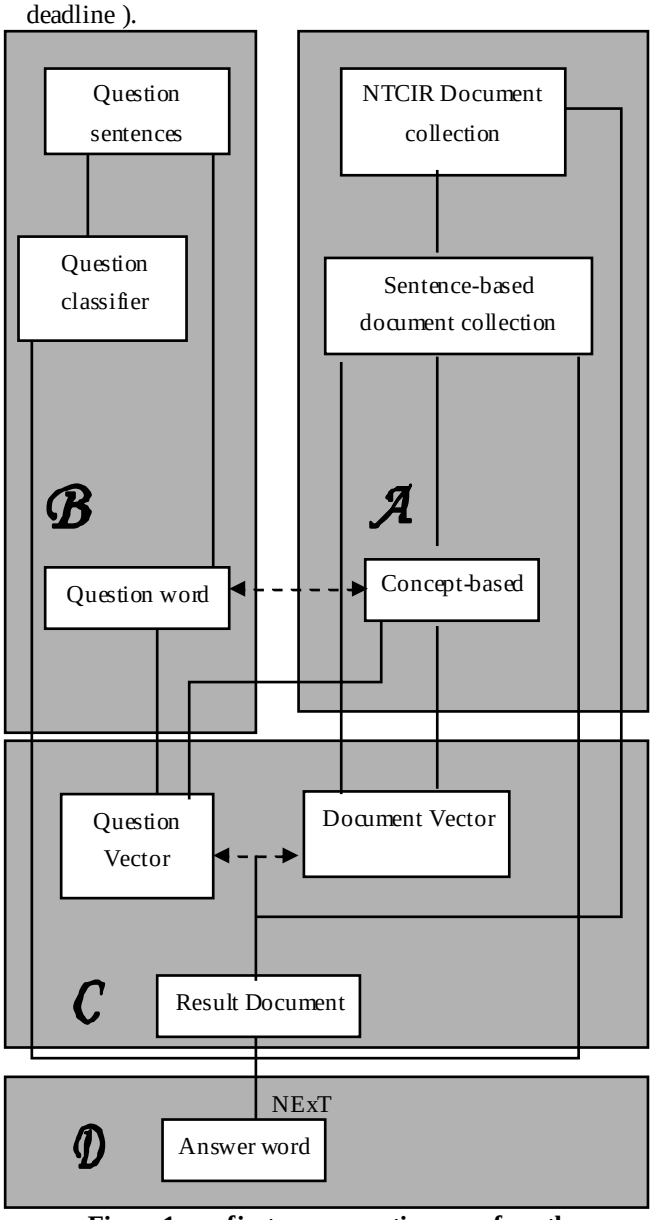

Figure1: first generation of the CBVSM-QAS

3.1 The first generation of CBVSM-QAS

The first generation of the CBVSM-QAS was created using the CBVSM model to extract the candidate documents from the entire newspaper database collection (Mainichi Newspaper collection year 1998 & 1999 and Yomiuri Newspaper collection year 1998 & 1999). The retrieval for the answer word is done by the Name Entity Extraction Tools (NeXT, developed by Masui,Suzuki and Fukumoto[1]). The architecture of the first CBVSM-QAS is illustrated in Figure 1. The architecture of the system can be separated into 4 main sections. Section A is the section of generating the concept-based vector. Section B is the section of processing the question. Searching process for candidate documents is done in section C, while the extraction of the answer word is done in section D of the system.

It is found in our study that accuracy of the retrieval almost failed if the calculation of the documents' vector done directly for each existing document. In the raw newspaper documents, the document size is too large that the words characteristic (words' vector) for the words contained in the question sentences are not emphasized in the document vector. In order to solve this problem, the sentence-based document method was proposed (refer section A of Figure 1). Each document was divided to sub document, composed by each sentences from the raw documents. The sub-documents then will go through the morpheme analyzer of Chasen[2] and creating a concept-based, before the vector of each word (concept-based vector) and the vector for each sentences base documents (document base vector) are calculated using the method explained before.

The question sentences, as given in the NTCIR's QAC2 subtask 1, then will also processed using the same method, in order to produce the vector for the question sentences. After the question sentences processed by the Chasen to generate the question vector, the words contained in the question vector are compared to the words in the concept-based. The words that are contained in both will be selected as the words to be search (question words). The words contained in the concept-based are limited to 10,000 words due to the limit of the amount of computing resources. This means words that are not contained in the 10,000 words of concept-based will not be consider as the question words.

At the same time, the questions are processes through the question classifier to identify the question type (section B). The question types are divided as below;

- Person: the question appointing to the person's name
- Organization: the question appointing to the organization / association name.
- Location: the question appointing to place/ location
- Time: the question appointing to specific time or a period of time.
- Money: the question appointing to answer concerns with the currency of some countries.
- Date: the question appointing to day or date.
- Accuracy: the question appointing to percentages of some numeral data.
- Others: the question appointing subjects other than classified above.

As mention in chapter 2 of this paper, the searching process for the answer document is executed by comparing the question vector and each document vector (section C). The system then will sort out the similarity degree and select the top 3 of the result, which is referring to the sub documents with the most related contents with the given questions.

The result documents, after extracted from the main document collection, then are being process through the NExT. In this process the proper noun contained in the text, will be extracted out (section D). Referring to the result of the question classifier, the answer word will be chosen from the extracted nouns.

3.1.1 The performance evaluation of the first generation system

By the reason of time limitation, the first generation of the CBVSM-QAS works with very limited performance. The main cause of the poor performance of this system was the shallow knowledge in creating the rules of question classifier and the system failure to recognize the answer word from the extracted documents.

On the question classifier, about 35% of the questions are hardly classified as the result of the weakness of the classifying rules implemented in the system. For the questions that succeed to be classified by the question classifier, the system will depend on the performance of NExT to identify the answer word. As the NExT will only works with the proper nouns to be identified, common nouns will probably be abandoned by the system. Poorly the system only achieved 0.018 of system score on the NTCIR-4's QAC2 subtask 1. However, the attempt of creating a question answering system with the implementation of concept-based vector space model by NUT continues, as we believe good answers are able to achieve if only the method of question classification and extraction of the answer word could be improved. As a strong support to our belief, the concern document (the document that contains answer for the questions), in fact, did come to the top of the list during the comparison of the question sentences' vector and the document base vector performed during the searching process.

3.2 The second generation of the CBVSM-QAS

Realizing the failure of the first generation system, the second generation system was build with some modification on the system's structures. The question classifier which is hard to fix the classifying rules has

been pulled out from the second system. The search process is still using the same concept with the previous one. Since the first CBVSM-QAS was too depending on the NExT performances, the second generation system improved by implementation of new method of extracting the answer word. The system's architecture is explains by Figure 2.

Section A of this system, which refer to the generation of concept-based and document base vector, remains the same as the previous one.

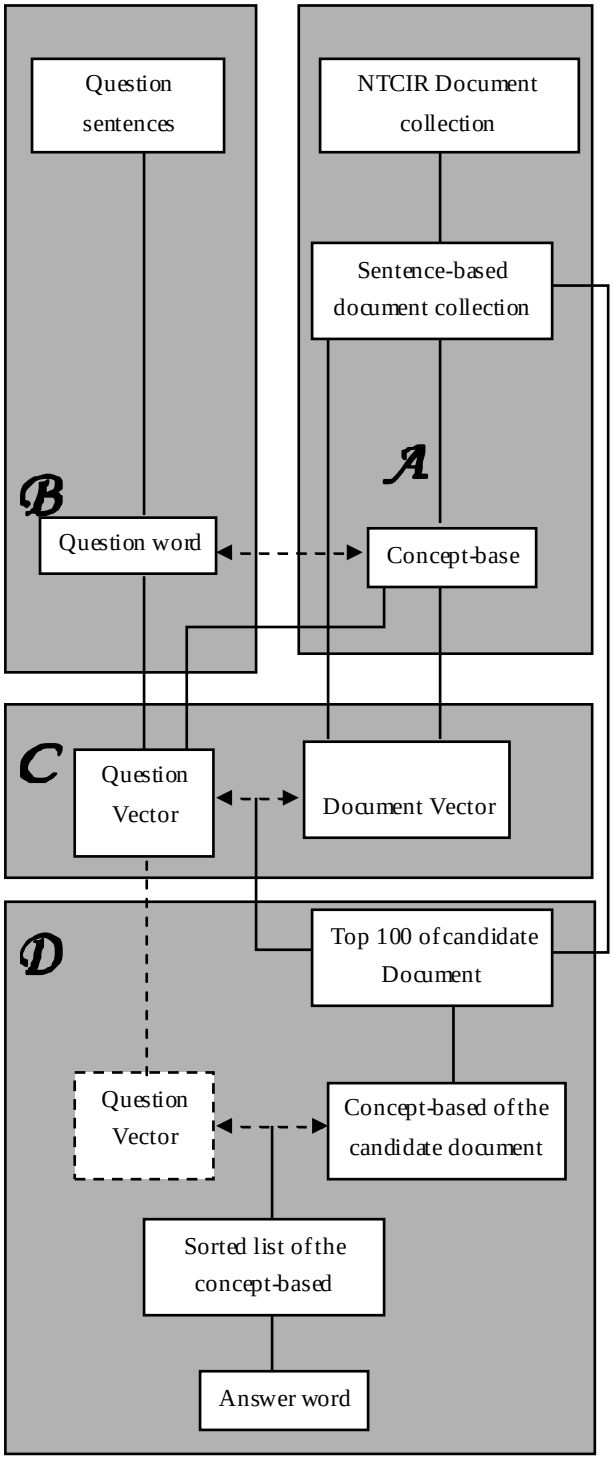

Figure 2: second generation of the CBVSM-QAS

Since the pattern matching was used to classify in the first generation system, a very complicated rules of pattern matching is needed to cover any type of question. These conventional ways of setting hundred of rules of pattern matching would surely works properly only if the rules can be written perfectly, but it need a great afford to complete it. Instead of using the question classifier, we have modified the system by skipping the question classifier and implementing the 100-documents concept-based retrieval model during the answer word extraction process. The 100-documents concept-based retrieval model also expected to gain better result comparing to the former structure. Accordingly, the question sentences, without processed through the question classifier, are straightly converted to question sentences vector by the same method as in the first system.

During the search process (section C), after the comparison of the question sentences vector and the document base vector is executed, the system will choose out top 100 of the related document instead of choosing most related document as the answer document in the previous system.

The selected documents, which are referring to the sentence base document, then will go through the process of generating the concept-based of its own collection. Since this collection differs greatly from the main collection in the concept of words contained, almost of the words contained in this document collection are able to be store in this concept-based without bothering the limit of 10,000 words of the concept-based. Here, the question once again will be check over the new concept-based to choose the words that are included in the new concept-based as the question word. This is conducted due to the differences of the words contained in the whole documents concept-based and the 100 document's concept-based. Some of the words especially the words with low frequency of appearance probably being drop out from the whole document's concept-based are able to take part in the 100-document concept-based. Accordingly, a more accurate value of the question sentences vector generated. The question sentences vector and the concept-based vector of the 100 documents then will be used to calculate the scalar product of the question sentences and each word from the concept-based. The main idea is base on the word which is having a close value (bigger cosine co-efficient) to the question sentences might be the answer word of the question.

3.2.1 The performance evaluation of the second generation system

In this second generation system, the problem occurred due to the question classifier was avoided by not classifying the question itself.

The second generation system was able to process the

question querying for dates. For the question such in the QAC2-10003-01, "When was Shochiku, a long-established group in the theatrical world, founded?" the system succeed to extract the answer as "year 1902". Comparing to the first generation of the system, the first generation was totally out due the system were unable to classify the question.

For the question that concerning person's name as in the question QAC2-10009-01, "What is Onodera Shotaro's real name?" proper answer still cannot be extracted by the system. The main reason was for this question, the words that were selected as query words (in fact, the words that is contained in the concept-based of the entire documents) was only the words "what" and "real name". It seems that the word "Onodera Shotaro" only appears in the entire newspaper document for a very several times that the appearance frequency of the word are too small to be selected in the concept-based. This is resulting the unrelated candidate document was extracted from the database. The words that containing the words "what" and "real name" was selected without considering whether the word "Onodera Shotaro" contains in the particular document or not. The problem also appears in the question QAC2-10010-01, "Where was Ishinomori Shotaro born?" which only the words "where" and "born" was selected as query words and question QAC2-10012-01, "where does the writer, C.W.Nicole, lives?" which only the words "where" and "writer" was selected.

For question concerning the place and organization, the system shows different performance for different question. For some of the question, the system somehow able to get the expected answer to top 3 of the answer word (referring to the NTCIR-4 QAC2's subtask 1, the candidate answers were submitted as 3 candidate answers. For question QAC2-10103-01," The highest peak in the seven continents of the world is Mr. Everest. Which mountain is the highest peak in each continent?" the answer "Kilimanjaro" and "McKinley" returned as one of the top answer.

For the question classed as "others" in the first system, the second system also shows inconsistent result as for the question QAC2-10124-01, "What are the names of the satellites of Jupiter?", the systems returns the answer as "Europa" as the first candidate. Unfortunately, the system fail to answer other question such as question QAC2-10183-01, "What are Misora Hibari's famous hit songs?".

4. Conclusion and future plans

From the result of the attempt of implementing the CBVSM into the question answering machine, the characteristic of the CBVSM had been confirmed.

The CBVSM-QAS performs well if the most of the nouns contains in the question sentences are selected as query words, which means the all the query words are contained in the concept-based. The CBVSM-QAS will perform badly in the reverse situations.

In the query words-fully selected situation, inaccurate vector might be produced due to the compound words' problem.

NUT's research continues on how to improve the performance of the CBVSM-QAS. Some of the plans are already proposed and going to be implemented and evaluated in the CBVSM-QAS.

1) Generation of noun-based concept-based model

In the question answering system, whether in the question sentences nor the in the answer word, the most useful words is the nouns. Nouns should be the most important words in the question sentences. Nouns also are the state of most of the answer words. These means, by eliminating the words other than nouns, the similarity degree of the question vector and candidate document can be improved. The elimination also will somehow solve the limited number of words in concept-based by placing only the important word in the concept-based. The elimination of the words is executed by sorting the words into verb, nouns, post positional practical words and adverb. Only the nouns words should be selected to be inserted into the concept-based. By the implementation of the noun-base concept-based the number of nouns contains in the concept-based certainly will be increased.

2) The revision of the compound words' vector

Phrase such as "shudanboukoujiken" (group violence incident), or the words such as "kaseitansaki" (Mars investigation plane) are presently divided into separated words' vector. "group violence incident" is a phrase that refers to a specific incident that should be taken as one word. Unfortunately the phrase is presently separated onto "shudan"(groups), "boukou"(violence) and "jiken"(incident). These kinds of words are massively constructed in the concept-based especially for the phrase that refers to technical terms.

In the concept-based, words' characteristic is represented by the neighborly concurrences between the words. For that reason, if the morpheme analysis of the words is not performed properly, the neighborly concurrences between the words cannot be represented correctly. This might cause some inaccurate vector retrieved for the particular query. The problem should able to be solved by identifying the compound words before the construction of the concept-based.

5. References

[1] F.Masui, N.Suzuki and J.Fukumoto. Development of the Name Entity Extraction Tools (NExT) for text processing. The 8-th Language Processing Society's annual journal, pp.176—179,2002.

[2] Y.Matsumoto, A.Kitauchi, T.Yamashita, Y.Hirano, H.Matsuda, K.Takaoka, M.Asahara

[3] T.Kato, S.Shimada, M.Kumamoto, and K.Matsuzawa, Idea-deriving information retrieval system. Proc of first NTCIR Workshop on Research in Japanese Text Retrieval and Term Recognition, pp. 187-193, 1999.

[4] R.Baeza-Yates, B.Ribeiro-Neto. Modern Information Retrieval, ADDISON WESLEY,1999.

[5]S. E. Robertson and K, Sparck Jones,.Relevance weighting of search terms. Journal of the American Society for Information Sciences, 27(3):129-146, 1976.

[6] Boris Galitsky, Natural Language Question Answering System, 2003.