A method for GeoTime information retrieval based on question decomposition and question answering

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Abstract

In this paper, we report the evaluation results of our GeoTime information retrieval system at NTCIR-8 GeoTime. We participated in the Japanese mono-lingual task (JA-JA). Our proposed method for GeoTime information retrieval is based on question decomposition and question answering.

We demonstrated that the proposed method is able to accept GeoTime questions and retrieve relevant documents to some extent. However, there is still room to improve the effectiveness of retrieval. In per-topic evaluation results, we can find there are some topics that cannot be appropriately handled by our method, and therefore the method lacks in robustness in terms of variety of GeoTime questions.

Introduction

- We participated in the Japanese mono-lingual (JA-JA) task.
- Our proposed method for GeoTime information retrieval is based on
  - Question decomposition and
  - Question answering.
    - GeoTime information retrieval can be regarded as one special case of IR4QA, because a query submitted to a system is a natural language question in typical situations.
    - We may straightforwardly consider documents that have good answer candidates as documents relevant to the query.

Related work

- GeoTime information retrieval may be regarded as a special case of IR4QA.
  - Many approaches to IR4QA introduce some extensions to treat natural sentence questions or question types.
  - Their foundation are information retrieval systems[Sakai et al. 2008].
- There are some text processing method based on the result of question answering system.
  - [Mori et al. 05] proposed a method for multi-answer-focused summarization using a question-answering engine.
    - Importance of each sentence is calculated based on the scores of answer candidates appeared in the sentence.
- Our approach to GeoTime information retrieval takes the same kind of approach as the latter researches.

T.Sakai et al. Overview of the NTCIR-7 ACLIA IR4QA task. In Proc. of the Seventh NTCIR Workshop Meeting (2008)
T.Mori et al. Multi-answer-focused multi-document summarization using a question-answering engine. ACM Transactions on Asian Language Information Processing, 4(3):305-320 (2005)

- GeoTime questions are usually complex questions, which have multiple interrogatives, like when, where, etc.
- We suppose that each GeoTime question is able to be decomposed into a set of simple factoid questions.
  - <*Q*, *interrog*>
    - *Q* is a simple question with one interrogative *interrog*.
- These simple factoid questions may be handled a factoid question-answering system.

Algorithm 3.1: DECOMPOSEQUESTION(Qc)

comment: returns a set of tuples of $\langle Q, interrog\rangle$, where Q is a simple question with one interrogative $interrog$, which is obtained by the decomposition of an inputted complex GeoTime question Qc.

global $InterrogPats$
comment: $InterrogPats$ is a set of patterns that match with interrogatives in question sentences.

procedure PATTERNMATCH($Str, Pats$)
comment: returns a set of tuples of position $\langle PosS, PosE\rangle$, where $PosS$ and $PosE$ are the start and end positions of a substring of Str matched with one of patterns $Pats$.
return $(\{\langle PosS, PosE\rangle\})$

procedure SUBSTR($Str, \langle PosS, PosE\rangle$)
comment: returns a sub-string $SubStr$ of Str that starts from position $PosS$ and ends at position $PosE$.
return (SubStr)

procedure DELSUBSTRS($Str, Matches$)
comment: returns a string $Str1$ that is obtained by deleting all substring expressed by $Matches$ from a string Str.
return $(Str1)$

main
$Ms \leftarrow$ PATTERNMATCH($Qc, InterrogPats$)
$Qs \leftarrow \bigcup_{M \in Ms}\{$(DELSUBSTRS($Qc, Ms\backslash\{M\}$), SUBSTR($Qc, M$))$\}$
return (Qs)

- The algorithm calls the factoid question-answering system to obtain answer candidates and their scores for all of the simple questions.
- <*D*,*interrog*,*AC*,*Sr*,*Sw*>
  - *D*: document
  - *Interrog*: interrogative
  - *AC*: answer candidate
  - *Sr*: raw score of *AC*
  - *Sw*: weighted score of *AC*

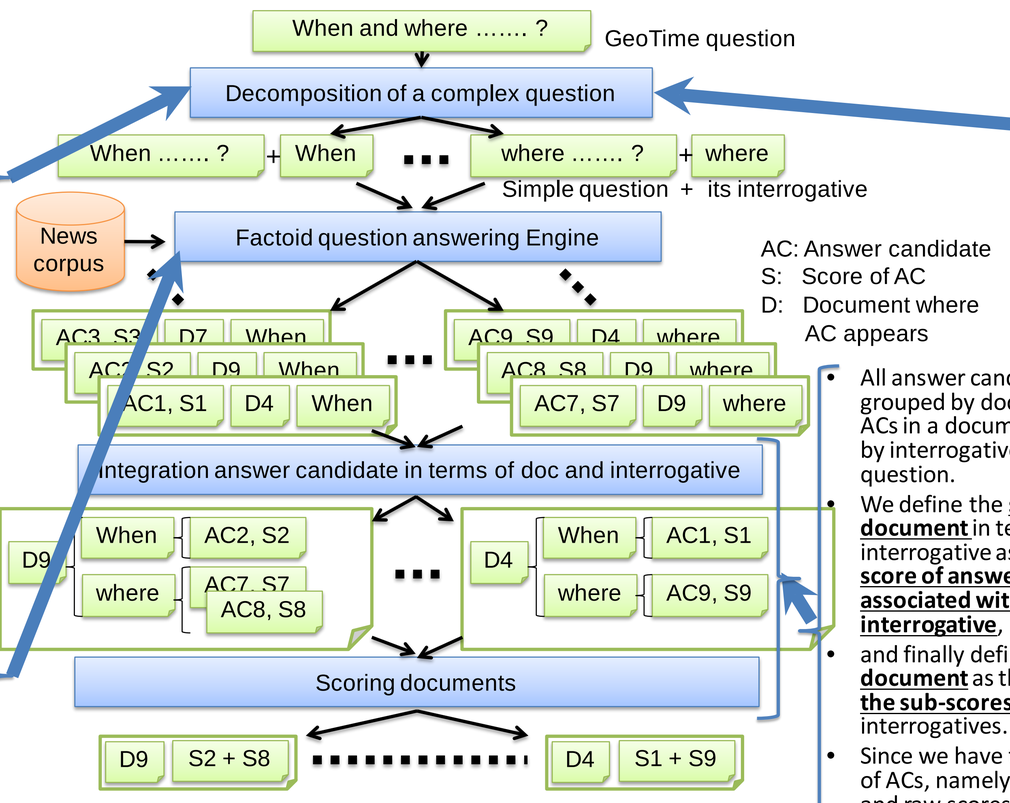
Algorithm 3.3: GETALLANSCANDS(Qs)

comment: returns a set of tuples of $\langle D, interrog, AC, Sr, Sw\rangle$, where AC and D are an answer candidate and a document in which the answer candidate appears. $interrog$ is the interrogative asked in a decomposed question. Sr and Sw are the raw and weighted score of the answer candidate. The inputs Qs is a set of decomposed questions.

procedure QA(Q)
comment: returns a set of tuples of $\langle AC, D, Sr, Sw\rangle$ for the question Q by using a factoid question-answering system.
return $(\{\langle AC, D, Sr, Sw\rangle\})$

main
$ACs \leftarrow \{\}$
for each $\langle Q, interrog\rangle \in Qs$
do { $As \leftarrow$ QA(Q); **for each** $\langle AC, D, Sr, Sw\rangle \in As$ **do** $ACs \leftarrow ACs \bigcup \{\langle D, interrog, AC, Sr, Sw\rangle\}$ }
return (ACs)

Proposed Method



- Example GeoTime qestion (GeoTime-0003)
  - いつ、どこでポール・ニッツは、亡くなりましたか？
    - (When and where did Paul Nitze die?)
- Decomposed questions
  1. いつポール・ニッツは、亡くなりましたか？
     - (When did Paul Nitze die?)
  2. どこでポール・ニッツは、亡くなりましたか？
     - (Where did Paul Nitze die?)
- Our current implementation of question decomposition is based on a simple pattern-match.

- All answer candidates (ACs) are grouped by document, and then ACs in a document are grouped by interrogative of simple question.
- We define the **sub-score of document** in terms of an interrogative as the **maximum score of answer candidates that associated with the interrogative**,
- and finally define the **score of document** as the **summation of the sub-scores** over all interrogatives.
- Since we have two types of scores of ACs, namely weighted scores and raw scores, two scoring strategies, **Strategy 1** (**weighted score**) and **Strategy 2** (**raw score**), are prepared, respectively.

Algorithm 3.4: SCOREDOCS($ACs, Strategy$)

comment: returns a set of tuples of $\langle D, S\rangle$, where S is the score of document D.
procedure DOCS(ACs)
comment: returns a set of all documents appeared in ACs.
return $(\{D\})$

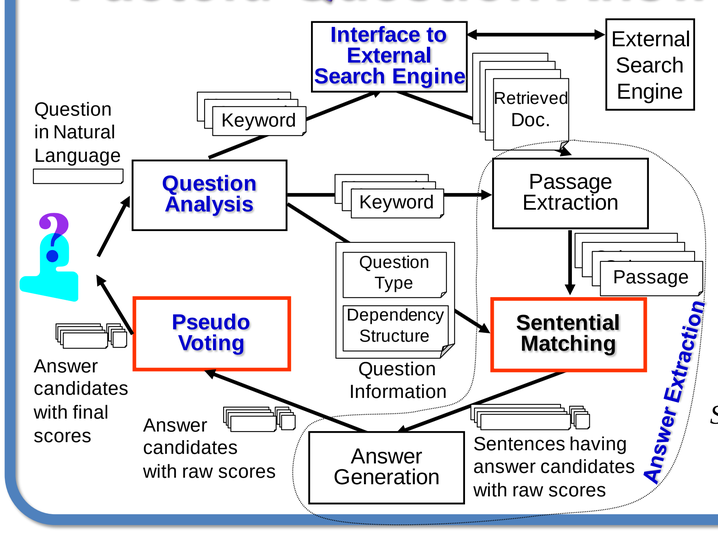
procedure INTERROGS(ACs)
comment: returns a set of all interrogatives appeared in ACs.
return $(\{Interrogative\})$

procedure SCOREDOC1(D, ACs)
return $\sum_{i \in \text{INTERROGS}(ACs)} \max_{\langle D,i,AC,Sr,Sw\rangle \in ACs} Sw)$

procedure SCOREDOC2(D, ACs)
return $(\sum_{i \in \text{INTERROGS}(ACs)} \max_{\langle D,i,AC,Sr,Sw\rangle \in ACs} Sr)$

main
$DSs \leftarrow \{\}$
for each $D \in$ DOCS(ACs)
do { **if** $Strategy == 1$ **then** $DSs \leftarrow DSs \bigcup \{\langle D,$ SCOREDOC1(D, ACs)$\rangle\}$ **else if** $Strategy == 2$ **then** $DSs \leftarrow DSs \bigcup \{\langle D,$ SCOREDOC2(D, ACs)$\rangle\}$ }

Factoid Question Answering System



- **It is difficult to make QA systems high precision with one monolithic method.**
  - There is a trade-off relation between informativeness and robustness of analysis in each processing technique.
    - More informative ←→ Less informative
    - Less robust ←→ More robust
- We employ **multiple complementary methods** in order for our QA system to have a variety of informativeness and robustness.
- Implementation: **Raw score** for an answer candidate ***AC*** in the ***i***-th retrieved sentence $\boldsymbol{L_i}$ with respect to a question sentence $\boldsymbol{L_q}$.

$$S(AC, L_i, L_q) = \underbrace{Sb(AC, L_i, L_q)}_{\text{Bi-gram}} + \underbrace{Sk(AC, L_i, L_q)}_{\text{keyword}} + \underbrace{Sd(AC, L_i, L_q)}_{\text{Dependency between an answer candidate and a keyword}} + \underbrace{St(AC, L_i, L_q)}_{\text{Question type consistency}}$$

- Many existing QA systems exploit global information about answer candidate.
  - **Voting method --- boosting the score for answers that occur multiple times** [Clarke 01, Xu 03].
- Pseudo voting [Mori 05]
  - Since our method continues searching for answers until scores of ***n different*** answers are fixed in n-best search, the system may find ***other answer candidates that have same surface expression***.
  - We can **use the partial frequency information** with regard to found answer candidates.
  - **Weighted score** $\boldsymbol{S^v(AC,L_q)}$ for an answer candidate ***AC*** is:

$$S^v(AC, L_q) = (\log_{10}(\underbrace{freq(AC, AnsList)}_{\text{Frequency}}) + 1) \cdot \max_{L_i} \underbrace{S(AC, L_i, L_q)}_{\text{Raw score}}$$

where ***AnsList*** is the list of answer candidates whose scores are fixed.

Experimental Results and Discussion

- We conducted four runs shown in Table 3.
- The difference among the runs is due to:
  - Scoring strategy and
  - Parameter settings of the question-answering system.

Table 1: Description of system parameters

a:	Number of answers to be searched.
d:	Number of documents to be retrieved.
ppd:	Maximum number of passages retrieved from one document.
p:	Number of passages to be considered in the retrieved documents.
pwin:	Number of sentences in one passage.

Table 2: Common parameter settings of the question-answering system

d	pwin	ppdoc
250	3	3

Table 3: Submitted runs

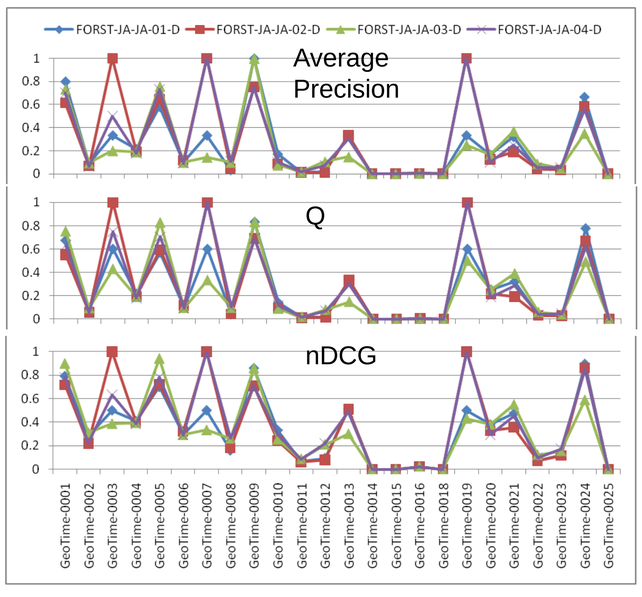
Run ID	Strategy	a	p
FORST-JA-JA-01-D	1 (weighted score)	10	30
FORST-JA-JA-02-D	2 (raw score)	10	30
FORST-JA-JA-03-D	1 (weighted score)	20	60
FORST-JA-JA-04-D	2 (raw score)	20	60

Table 4: Mean of each evaluation metrics

Run ID	mean AP	mean Q	mean nDCG
FORST-JA-JA-01-D	0.233	0.259	0.332
FORST-JA-JA-02-D	0.286	0.284	0.372
FORST-JA-JA-03-D	0.206	0.238	0.324
FORST-JA-JA-04-D	0.276	0.287	0.377

- Strategy 2 (raw score) is superior to Strategy 1 (weighted score).
- The parameter settings of question answering do not seriously affect to the effectiveness in GeoTime retrieval.
- There are no statistically significant difference among runs according to the Wilcoxon matched pairs signed rank sum test.

- There are some topics that cannot be appropriately handled by our method.
  - The method lacks in robustness in terms of variety of queries.
- Especially, the question decomposition module failed to decompose GeoTime questions in some cases.



- Failures because of lack of patterns.
  - GeoTime-0010:いつITERの設置とその建設予定地が決定しましたか？
    - (When was the decision made on siting the ITER and where is it to be built?)
  - GeoTime-0018: 2002年に合衆国がある国に侵攻したのは何月何日でしたか？
    - (What date was a country was invaded by the United States in 2002?)
- Failures because the given questions consist of two separate questions.
  - They cannot be handled by our question-answering systems.
  - We need a system for information access dialogue (IAD) task like NTCIR-5 QAC
  - GeoTime-0015:どのアメリカンフットボールチームが、2002年のスーパーボウルで優勝しましたか、また、試合はどこで開催されましたか？
    - (What American football team won the Superbowl in 2002, and where was the game played?)
  - GeoTime-0020:もっとも最近に国連に加盟したのはどの国ですか、また、加盟したのはいつですか？
    - (What country is the most recent to join the UN and when did it join?)
  - GeoTime-0023:欧州連合の最大の規模拡大が生じたのはいつですか、また、どの国がメンバーになりましたか？
    - (When did the largest expansion of the European Union take place, and which countries became members?)