# Utilization of histories by country in question-answering system to solve world history essay type questions

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## Abstract

We propose a query expansion method which uses the book of histories by country as a knowledge source for the question-answering system about world history complex essay type questions from the University of Tokyo's entrance examination. As the result of the experiment, the recall increased distinctly but the precision decreased instead. Therefore, there was an improvement from the viewpoint of summarization's preprocessing.

## 1 Introduction

Research on real-world complex question-answering (QA) has flourished in recent years. Notable examples are the QA Lab tasks at the NTCIR workshop[1] (Shibuki et al., 2017; Shibuki et al., 2016; Shibuki et al., 2014) and Todai Robot Project[2] (Fujita et al., 2014). The QA Lab has a task for essay type questions of Japanese university entrance examinations about world history. There are two kinds of essay type questions: complex essay type questions with limits of about 500 characters and simple essay type questions with limits of less than or equal to 200 characters. We are developing a complex essay type question-answering system (Sakamoto et al., 2017). The task of satisfying the information need is addressed by obtaining information from textbooks and a glossary as knowledge sources. Also, since essays have maximum numbers of characters, the system's approach is an extractive

multi-document summarization aimed at satisfying the information need. The system pipeline consists of a first part which retrieves needed information from knowledge sources, and a second part which summarizes retrieved information adequately. This system achieved a certain result, but there is still room for improvement. For example it can not retrieve relevant descriptions which need to be included in the answer. In the paper (Fukuhara et al., 2017), we investigated the correspondence between gold standards[3] and knowledge sources. Also, we noticed the 85.1% of descriptions in gold standards corresponded to knowledge sources, where the rate was calculated in characters. Therefore, in regard to the problem of the former retrieval part of the pipeline, low ability to retrieve relevant descriptions from knowledge sources is worse than shortage of knowledge sources. We think that there are two reasons why the system cannot retrieve relevant descriptions. The first reason is that expressions in relevant descriptions do not match expressions in questions. The second reason is that expressions in relevant descriptions are not included in the questions. When we focus on the latter, the system needs a framework to expand phrases in a question in order to associate them to phrases in relevant descriptions. For example a person who learnt world history can associate "Napoleon" with "French campaign in Egypt" and "battle of Waterloo". We developed a module based on the above. According to the book (Sato, 2016), there are four types of complex

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[1]http://research.nii.ac.jp/ntcir/index-en.html
[2]https://21robot.org/

[3]As gold standards, we used answers in Akahon, which is a book series of Japanese universities' past examinations. https://akahon.net/

Figure 1: A translation of an example of complex essay type questions

Egypt, which created a brilliant ancient civilization, went on to maintain an unbroken line of history for 5,000 years. This history was based in the nation's rich land, but any discussion of it must include the political powers which came from near and far and left their profound marks, and their relationship with the active response by Egypt.

Paying close attention to this background, provide an overview of the development of Egypt since the birth of its civilization, taking into consideration both 1. the interests of those arriving in Egypt and the reasons for their advances into Egypt, and 2. the policies and actions taken by Egypt in response to these advances. Limit your answer to 18 lines (540 Japanese characters) or less. Use each of the eight terms below once, and underline each term when it is used.

Battle of Actium, Islam, Ottoman Empire, Saladin, Nile River, Nasser, Napoleon, Muhammed Ali

Figure 2: A translation of a gold standard of the question

Independent dynasties flourished for many years in ancient Egypt, centered on the Nile River, but were conquered by Alexander the Great, et al. Cleopatra, in Ptolemaic dynasty Egypt, allied with Antony during the civil war in Rome, hegemon of the Mediterranean. Together, they fought Octavian, but were defeated at the Battle of Actium, and Egypt became a Roman province. The Islamic forces which unified the Arabian Peninsula during the 7th century BCE took advantage of the conflict between the Eastern Roman Empire and Sasanian Empire Persia to expand their territory, conquering Egypt. In the Fatimid Caliphate, which inherited part of the territory of the Muslim Empire, Saladin became vizier in 1196, and fought the Crusaders, who sought to recapture the holy land of Jerusalem from the Islamic forces. Similarly, the Mamluk Sultanate, established in Egypt during the fight against the Crusaders, was invaded by the Ottoman Empire and fell. In the modern era, French leader Napoleon invaded Egypt to break the communication line between Britain and India, proclaiming himself a liberator, but he met with opposition from the people. When the war against France broke out, Muhammed Ali, dispatched to Egypt by the Ottoman Empire, established a dynasty in Egypt. Britain became involved in the internal politics of Muhammed Ali's dynasty, and the country became a British protectorate. Nasser launched a revolution in 1952, overthrew the monarchy, and led a war against Israel.

essay type questions about world history in the University of Tokyo's entrance examination. One of them asks to describe the course of history of a country or an area.[4] The Figure 1 shows an example of this type of complex essay type questions and the Figure 2 shows an example of gold standards of the question. In this question, if knowledge sources written about historical events about Egypt are available, it might be possible to conjecture phrases which are not written in the question. As one of such knowledge sources, there is a book of histories by country (Imaizumi et al., 2007) as shown in Figure 3. The book plainly describes a specific country's important events on multiple themes such as war or politics. Based on the

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[4]The other three types are *"to describe historical courses and relations among several areas"*, *"to describe relations between some specific elements and historical courses in each area"* and *"to compare two or more historical events"*.

background above, we proposed a query expansion method which uses the book of histories by country as a knowledge source for the question-answering system about world history complex essay type questions from the University of Tokyo's entrance examination. We define the knowledge sources for writing essay type answers in the paper (Sakamoto et al., 2017) as *answer knowledge sources* (AKS), and the knowledge source for the query expansion in this paper as *query expansion knowledge source* (QEKS).

## 2 The Structure of the Complex Essay Type Question

Figure 1 shows an example of the complex essay type question of world history, which is an English translation from the original Japanese version. The question contains additional text besides the main essay topic. The first paragraph gives background information, and the texts below the essay topic are the constraints for writing the essay. The constraints include a length limitation of *"18 lines (540 Japanese characters) or less"*, a condition of keywords that have to be included in an answer, which are *"Battle of Actium, Islam, Ottoman Empire, Saladin, Nile River, Nasser, Napoleon, Muhammed Ali"*, a geographical condition of *"Egypt"*, a chronological condition of *"since the birth of its civilization"* and a theme condition that the answer has to be written while focusing on *"1. the interests of those arriving in Egypt and the reasons for their advances into Egypt, and 2. the policies and actions taken by Egypt in response to these advances"*. Note that the keywords are not concentrated in textbooks or glossary and there is no passage including all or many keywords, so there is a need to find descriptions including the keywords from multiple passages in textbooks and glossary.

## 3 Related Work

### 3.1 Non-Factoid Type Question-Answering

The questions of previous works about non-factoid type question-answering (Cohen et al., 2018; Agichtein et al., 2015; Mitamura et al., 2010) are mostly brief such as "Why doesn't U.S. ratify the Kyoto Protocol?". However, the complex essay type question is much longer and has many constraints

such as a length limitation, keywords that have to be included in an answer, a geographical condition, a chronological condition, a theme condition and so on.

### 3.2 Extractive Multi-Document Summarization

Our approach to solve the questions is an extractive multi-document summarization. Extractive multi-document summarizations (Erkan and Radev, 2004; Ng et al., 2012; Donghong and Yu, 2008) generally generate summaries consist of only significant events retrieved from AKS and reduce redundancy as far as possible. By contrast, the proposed method has two steps: to uncover the events which are the main points of the answer by using QEKS, and subsequently to retrieve the corresponding descriptions from AKS.

### 3.3 Query Expansion

The proposed method has a query expansion. Query expansion generally aims to cause the new query to match other semantically similar terms, with a thesaurus or WordNet, via automatic thesaurus generation, or techniques like spelling correction (Manning et al., 2009; Wollersheim et al., 2005), by contrast, the proposed method's query expansion aims to gain chronological and descriptive before-and-after relations by QEKS.

## 4 The Book of Histories by Country

We digitalized and used the book of histories by country. Textbooks and reference books which can be used as AKS describe many events, including relatively less important events, which are also described in detail as part of the narration. On the other hand, in the book of histories by country, the number of described events is smaller and only important events are outlined. Also, descriptions as they are in the book of histories by country are useless for generating essay type answers because they end with a sentence with a noun or noun phrase, and use symbol notation and so on as shown in Figure 3.

Since an essay type answer has a maximum number of characters, all the less important events can not be included in the answer, which instead has to cover important events in an extensive manner and also describe the details of each the important event.

(1) **National unity of Egypt**

| | |
|---|---|
| **Old Kingdom** | Period and the capital‐ ‐ ‐ the 27th〜the 22nd century B.C.E. ： The capital is **Memphis**<br>Formation ‐ ┌ ‐「**Egypt was the gift of the Nile**」 (**Herodotus** who is a Greek historian)<br>　　　　　　├ ‐Agriculture which uses rise and fall of water level of **the Nile** → need for joint work and control to manage the river<br>　　　　　　└ ‐Dynasty who integrates **Lower Egypt** as a delta area and **Nome** (a village) in **Upper Egypt** as a river valley appears<br>The period f **Pyramids** ‐ ‐ ‐ in the period of Fourth Dynasty, autocrat **Pharaoh** (king) reaches the peak prosperity<br>　　　　　　└ ‐ Pyramids of **Khufu**, Khafre and Menkaure in **Giza**<br>Downfall ‐ ‐ ‐ decentralization by weakening royal authority |
| **Middle Kingdom** | Period ‐ ‐ ‐ the 21st〜18th century B.C.E.<br>The capital ‐ ‐ ‐ transferred to **Thebes**<br>　　　　　　→ guardian deity **Ammon** (**Amun**) of Thebes becomes the chief deity<br>After the fall ‐ ‐ ‐ failing into turmoil because of invasion by Asian nomads **Hyksos** who have horses and tanks |
| **New Kingdom** | Period ‐ ‐ ‐ 1567 B.C.E.〜1085 B.C.E.<br>The capital ‐ ‐ ‐ **Thebes**<br>Formation ‐ ‐ ‐ to banish Hyksos and innovate their military technologies<br>　　　　　　to invade Syria and conflict with Mitanni and Hittites<br>**Akhenaten IV**<br>　(throne ： about 1351 B.C.E.〜about 1334 B.C.E.)<br>┌ ‐ To force people to have faith in the only one God **Aton** and<br>│　rename himself to Akhenaten<br>└ ‐ Transfer the capital to **Tell el-Amarna**<br><br>New Kingdom of Egypt |

Figure 3: A translation of an example of histories by country (history of Egypt)

Therefore, our approach is to uncover the phrases which are the main points of the answer by using the book of histories by country, and subsequently to retrieve the corresponding descriptions from AKS.

## 5 Retrieval from QEKS

The number of events described in the book of histories by country is relatively small, but there are still too many events to include them all in an answer. Somehow they have to be narrowed down. As shown in the Figure 1, the question focuses on Egypt and requires to write an answer on the theme of war as written in *"1. the interests of those arriving in Egypt and the reasons for their advances into Egypt"* and politics as written in *"2. the policies and actions taken by Egypt in response to these advances"*. We narrow down relevant phrases in the book of histories by country by using the above themes as basis. The paper (Kawazoe et al., 2014) proposes an ontology of world history which broadly covers historical events in detail. Considering a set of events in the ontology, we annotated each sentence in the book of histories by country with 51 tags[5] which become themes. Table 1 shows the annotated tags. In this way, we can find a set of sentences in the book of histories by country, which are associated with themes. We define the above as query expansion by themes.

Another method to narrow down phrases is to find connected phrases, for example "Napoleon" is associated with "French campaign in Egypt" and "French campaign in Egypt" is associated with "Rosetta stone". Like the example above, we listed associated phrases one by one. Usually, keywords as shown in Figure 1 are named entities. Also, the relation between "Napoleon" and "French campaign in Egypt" is judged by co-occurrence in the book of histories by country as written in "French campaign in Egypt by Napoleon (1798-99) ・・・ with this as a trigger, the nationalism was exalted" Therefore, in this paper, we extract named entities which are included in the book of histories by country as nodes and we link the nodes which are included in the same description. Figure 3. A network structure as shown in Figure 4 is built. By following the links, we can expand a named entity to other named entities. However, as expected in a book of histories by country, country names appear much more frequently than other named entities, so most nodes link to nodes of country names. If we use a network structure like the above, needless phrases are retrieved. Hence,

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[5] 50 tags refer to the set of events in the ontology of world history and 1 tag was created by us

| | |
|---|---|
| command by a weak agent | arrival of the peak period |
| extinguishing of family or dynasty | separation of an organization |
| transfer of capital | invasion |
| turmoil | banishment from a place |
| military advance | battle among countries |
| discovery | success of a weak agent |
| use of a technology | domination |
| independence of a country | expedition |
| war | defeat |
| loss of territory | trade |
| military victory | establishment of organization |
| support | to collect people |
| annexation | admission into an organization |
| opposition | dispatch of troops |
| expansion of territory | opening of war |
| international conference | approval |
| conclusion of treaty or agreement | management of an organization |
| opening a road | against law, system and/or establishment |
| military intervention | national independence movement |
| beginning | cooperation |
| political revolution | enforcement of laws, systems and policies |
| military defeat | to represent an organization |
| signature of a contract | attack on a person |
| democratic movement | ethnic migration |
| aggression | religious movement |
| establishment of dynasty or country* | (* Only this theme was created by us.) |

Table 1: Themes/tags annotated to the book of histories by country

we decided not to use country names as nodes of the named entities' network. We define the above as query expansion by named entities' network.

The keywords in a question are important clues to write an answer, and they suggest chronological boundaries of events that should be written. For example, with regards to "Napoleon", he was alive from the latter half of 18 century to the former half of 19 century, so descriptions in the book of histories by country, which include "Napoleon", are written about events around the same period. Since descriptions of history by country are written in chronological order as shown in Figure 3, the first and the last descriptions including keywords are chronologically the first and the last events respectively. Therefore, descriptions can be further narrowed down by removing descriptions which are out of the boundaries. This idea can be adopted to both query ex-

pansion by themes and query expansion by named entities' network.

## 6 Proposed Method

Figure 5 shows the proposed method's pipeline. The proposed method consists of two steps. In the first step, phrases associated with the question are extracted from QEKS. In the second step, phrases extracted in the first step are used as retrieval query, and descriptions which should be included in the answer are extracted from AKS. In the extraction of themes, themes such as "war" or "politics" are extracted from the question. This process should be automated in the future but the precision is too low at this time, therefore the second author manually did it. In the query expansion by themes, we find a set of sentences associated with the themes using annotated tags in Section 5, and gain a set of named en-

French campaign in Egypt by Napoleon (1798-99) ・・・with this as a trigger, the nationalism was exalted
French campaign in Italy ・・・Napoleon Bonaparte's frame rises
French campaign in Egypt by Napoleon ← the second coalition against France is organized
First French Empire ・・・on May in 1804 : Napoleon I as Emperor found it → the third coalition against France is organized in opposition to it
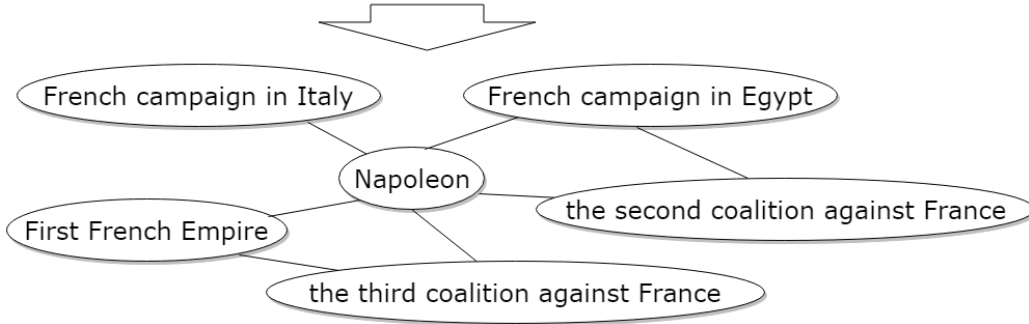


Figure 4: A translation of an example of how a named entities' network is built
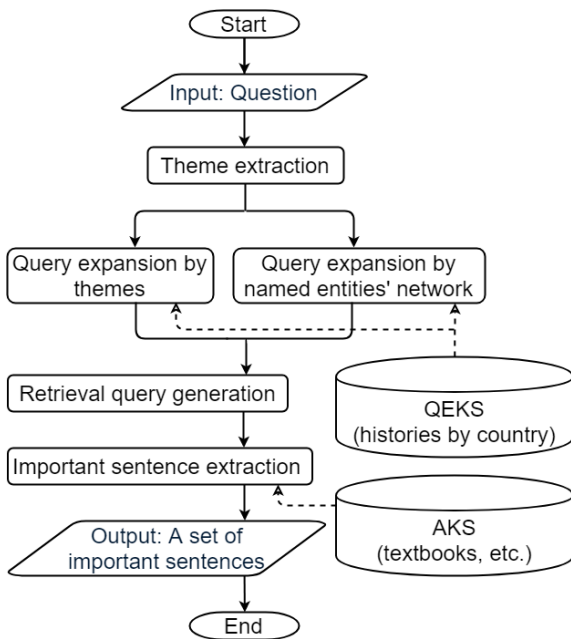


Figure 5: The proposed method's pipeline

tities from the sentences. In the query expansion by named entities' network, keywords in the question are used as starting nodes. By following the links of the named entities' network, we gain a set of named entities corresponding to nodes until $n$ nodes ahead from the starting nodes. When named entities' network are being built, named entities judged as "POS subcategory 3" or "country" in analysis results of Japanese morpheme analyzer MeCab[6] are removed. In the generation of retrieval query, we unite the two sets of named entities collected from both query expansions. In the extraction of important sentences, as with the paper (Sakamoto et al., 2017), all the passages[7] in which named entities as retrieval queries are included are retrieved from AKS, and sentences are extracted from the passages including the named entities. Note that, in the previous method in the paper (Sakamoto et al., 2017), all the passages in which the keywords, not the named entities, retrieval queries are included are retrieved from AKS, and sentences are extracted from the passages including the keywords, not the named entities.

## 7 Experiment

We investigated if there is an improvement with the proposed method compared to the previous method. In the experiment, we used two questions from the

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[6]https://taku910.github.io/mecab/
[7]a passage is a paragraph in textbooks or a description of a term in the glossary

| | Sentence | | | | Passage | | | |
|---|---|---|---|---|---|---|---|---|
| | Recall | | Precision | | Recall | | Precision | |
| | 2001 | 1999 | 2001 | 1999 | 2001 | 1999 | 2001 | 1999 |
| Previous | 0.133 | 0.123 | 0.024 | 0.118 | 0.656 | 0.695 | 0.080 | 0.394 |
| Proposed | 0.315 | 0.301 | 0.020 | 0.017 | 0.918 | 0.966 | 0.046 | 0.036 |

Table 2: Recall and precision of retrieving important sentences and passages

| | Recall | | Precision | |
|---|---|---|---|---|
| | 2001 | 1999 | 2001 | 1999 |
| Query expansion by themes | 0.846 | 0.647 | 0.647 | 0.647 |
| Query expansion by named entities' network | 0.615 | 1.000 | 0.485 | 0.654 |
| Intersection of both the results | 0.462 | 0.647 | 0.632 | 0.846 |
| Union of both the results | 1.000 | 1.000 | 0.510 | 0.567 |

Table 3: Recall and precision of query expansion (results of extractions from QEKS)

University of Tokyo's entrance examination of 2001 and 1999. We set the $n$ value of the named entities to 1, based on the result of a preliminary experiment. As evaluation index, we used a sentence-based recall $R_s$ and precision $P_s$ as follows.

$$R_s = \frac{\text{\# of retrieved important sentences}}{\text{\# of important sentences}} \quad (1)$$

$$P_s = \frac{\text{\# of retrieved important sentences}}{\text{\# of retrieved sentences}} \quad (2)$$

An important sentence is defined as a sentence of AKS which can be traced to gold standards. We also calculate a passage-based recall $R_p$ and precision $P_p$ as follows.

$$R_p = \frac{\text{\# of retrieved important passages}}{\text{\# of important passages}} \quad (3)$$

$$P_p = \frac{\text{\# of retrieved important passages}}{\text{\# of important passages}} \quad (4)$$

An important passage is defined as a passage including an important sentence.

## 8  Discussion

The results of the experiment are shown in Table 2. Although the results of the questions in 2001 and 1999 show little differences, on the whole they are both almost equal to each other. We reckon that there is no effect on the results from questions. Comparing the previous method and the proposed method, one can notice that the recall distinctly went up, but the precision went down instead. Therefore, there was an improvement from the viewpoint of summarization's preprocessing. Considering that the proposed method is the retrieval part of a complex essay type question-answering system, it is possible that descriptions which are not needed in the answer are removed by the part of the system devoted to summarization. In that sense, in the retrieval part, it is important to retrieve descriptions which are needed to write the answer comprehensively, so we put weight on recall rather than precision. Therefore, the fact that the passage-based recall increased remarkably is an important improvement, as indicated for example in the rise from 0.656 to 0.918 in the question in 2001 and from 0.695 to 0.966 in the question in 1999. Next, we discuss the effects of the query expansion by themes and the query expansion by named entities' network. In order to evaluate the result of the two query expansions, we define DQEKS as *descriptions in QEKS*, and important DQEKS as DQEKS that can be traced to gold standards. Also, we define output DQEKS as outputs of both query expansions that are not named entities but descriptions instead, and output important DQEKS as output DQEKS that can be traced to gold standards. We calculated the recall $R_e$ and the precision $P_e$ as follows.

$$R_e = \frac{\text{\# of output important DQEKS}}{\text{\# of important DQEKS}} \quad (5)$$

$$P_e = \frac{\text{\# of output important DQEKS}}{\text{\# of output DQEKS}} \quad (6)$$

In the retrieval by themes, DQEKS are sentences associated with themes right before extracting named entities. In the retrieval by named entities' network, DQEKS are sentences including the named entities of both source and target nodes. Also, we calculate recall and precision of the intersection and the union of DQEKS which are the output of both the query expansions. Table 3 shows the results. The precision of query expansion by themes is higher than the precision of query expansion by named entities' network. In terms of recall, we can not say which one is higher because of the difference between the two questions. However, the recall of the union adds up to 1.000. Therefore, they are complementary to each other. In the result of the intersection, the precision is higher than both the precisions of the single results. This may be able to improve the precision of the retrieval from AKS.

## 9 Conclusion and Future Work

In this paper, with regards to a question-answering system to generate an answer of a world history's complex essay type question of the University of Tokyo's entrance examination, we proposed a query expansion method which uses the book of histories by country. The proposed method has two steps: to uncover the phrases which are the main points of the answer by using the book of histories by country, and subsequently to retrieve the corresponding descriptions from AKS. As the result of the experiment with two questions of the University of Tokyo's entrance examination, the recall increased distinctly, while the precision decreased instead. Therefore, there was an improvement from the viewpoint of summarization's preprocessing. In the future we want to make the recall increase to 100%, while still considering the precision.

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