Question Answering Based on Temporal Inference

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Abstract. Inference approaches in Arabic question answering are in their first steps if we compare them with other languages. Evidently, any user is interested in obtaining a specific and precise answer to a specific question. Therefore, the challenge of developing a system capable of obtaining a relevant and concise answer is obviously of great benefit. This paper deals with answering questions about temporal information involving several forms of inference. We have implemented this approach in a question answering system called IQAS: Inference Question Answering System for handling temporal inference.

Keywords: Question answering system; temporal inference; several forms of inference.

1 Introduction

Advances in Natural Language Processing (NLP), Information Retrieval techniques (IR) and Information Extraction (IE), have given Question/answering systems (QA) a strong boost.QA have started incorporating NLP techniques to parse natural language documents, extract entities, resolve anaphora, and other language ambiguities [1]. In order to develop question answering capabilities, we believe that a large corpus of questions and answers that are based on temporal information should be discovered. In this paper, we focus on the task of question answering in Arabic by thinking of an approach which can improve the performance of traditional Arabic question answering systems for handling temporal inference. Obviously, any user is interested in obtaining a specific and precise answer to a specific question [2]. Therefore, the challenge of developing a system capable of obtaining a relevant and concise answer is obviously of great benefit. The challenge becomes huge when we try to automatically process a complex natural language such Arabic. This complexity is mainly due to the inflectional nature of Arabic. The situation gets worse, when we talk about the considerable lack of resources in general. Moreover, in our chosen field, research on temporal entity extraction in English, German, French, or Spanish, uses local grammars, and neural networks to detect temporal entities. These techniques do not work well directly for Arabic due mainly to the rich morphology and high ambiguity rate of Arabic.

In this paper, we propose a new approach dealing with the recognition and processing of temporal information for Question Answering (QA).

The remaining of this paper is organized as follow. In the next section, we give a short overview of QA systems with a special attention to the QA systems based on complex questions. After that, we describe our proposed approach and its different steps. Finally, we conclude this work and make suggestions for future researches.

2 Related Works

In this section, we present the earlier works related to question answering in Arabic. Despite extensive research in Arabic, the criteria represent a challenge to the automatic language processing systems [3]. In the last decade, the volume of Arabic textual data has started growing on the Web. Question-Answering systems represent a good solution for textual information retrieval and knowledge sharing and discovery. This is reason why a large number of QA systems has been developed and extensively studied recently. English, in particular, is very well served due to the fact that the majority of documents available on the internet are in English [4]. The question/answering systems in Arabic still few compared to the number of those developed in English, for instance. This is mainly due to the lack of accessibility to linguistic resources and the inflectional nature of Arabic.

Following a comprehensive survey of available Arabic QA systems, we realized that there are some well-known similar systems.

In fact, the technology of Arabic question answering has been studied since the 1970s starting with the AQAS system presented in [5]. This is the first system for Arabic. It is a knowledge-based QA system that extracts answers only from structured data.

ArabiQA is an Arabic question answering system dealing with factoid questions, integrates NER (Named Entity Recognition) module and adapts JIRS (Java Information Retrieval System) to extract passages from Arabic texts [6].

A deep study of sentence formulation and structures in Arabic interrogative continues with AQuASys [7] which is a Question Answering System designed to make it possible for the user to type in a question formulated in Arabic natural language, and designed to answer questions related to a named entity that can be of any type: person, location, organization, time, quantity, etc. Therefore, the system takes, as input, questions starting with interrogative words (من/who, ما/what, أين/where, متى/when, كم العددية/how many, كم الكمية /how much).

QArabPro [8], is an Arabic QA system that uses IR and NLP techniques to extract answers. It supports the factoid but excludes how and why.

Those approaches deal only with non-complex questions where the answers are selected from their corresponding short and simple texts. The challenge becomes greater when we try to create capabilities of processing complex questions and finding their answers from a collection of texts. An important component of this effort deals with the recognition and processing of temporal information for Question Answering (QA).

When asking a question that refers directly or indirectly to a temporal expression, the answer is expected to validate the temporal constraints. To achieve such functionality, QA systems need first, to deal with relations between temporal expressions and events mentioned in the question and, second, to rely on temporal inference to justify the answer. Whenever the answer to a question needs to be justified, if temporal expressions are involved, the justification must contain some form of temporal inference [9]. For example, the expected answer type of question Q1 is a Date:

Q1: متى تقلد المنصف المرزوقي رئاسة الجمهورية التونسية؟
Q1: When Moncef Marzouki has held the presidency of the Republic of Tunisia?

The expected answer type is an argument of the first event Evt1=تقلد / held the presidency which has two more arguments: المنصف المرزوقي/Moncef Marzouki and الجمهورية التونسية / Republic of Tunisia.

The answer to Q1: 12 ديسمبر 2011 / 12 December 2011, extracted from the context:

P1: The doctor was elected as the interim President of Tunisia on 12 December 2011 by the Constituent Assembly of Tunisia with 153 votes for, 3 against, and 44 blank votes.

P1 : انتخب الدكتور رئيساً مؤقتاً لتونس في 12 ديسمبر 2011 بواسطة المجلس الوطني التأسيسي بعد حصوله علي أغلبية 153 صوتاً مقابل ثلاثة أصوات معارضة وامتناع اثنين و 44 بطاقة بيضاء.

In the paragraph *P1*, the event *Evt2*=انتخب/ elected which has as arguments الدكتور/ the doctor and تونس/ Tunisia. The event *Evt1* differs from the event *Evt2*, but they are related. To justify the answer, these relations must be recognized into the temporal inference. In fact, it is through this example that we illustrate the importance of temporal inference to determine the full content.

In this paper, we present a Question Answering (QA) methodology to handle temporal inference by combining all these forms of inference.

3 The Importance of Temporal Information

In this section, we discuss some interesting applications that depend on temporal entity extraction to enrich our work. Time is an important dimension of any information space. However, in the last few years it has been studied in several areas.

- Temporal information is well-defined [10]: the relationship can be of the types before, overlap or after.
- Temporal information can be normalized [10]: every temporal expression referring to the same semantics can be normalized to the same value in some standard format.
- Temporal information can be organized hierarchically [10]: Temporal expressions can be of different granularities, e.g., of day type (December 20, 2015) or of year type (2015).

The temporal relationship between two events may allow answering a temporal query although no explicit temporal information is associated with the events [11].

Actually, processing questions that involve temporal inference relies on (1) the recognition of events/states and of entities that participate in them, (2) the relative ordering of events in the question and in the texts, (3) the temporal properties of the entities being questioned and (4) identification of the expected answer and its relations to temporal expressions mentioned in the question or candidate answers.

4 Proposed Approach

The proposed approach involves three main modules (Figure 1), namely :(1) question processing for interpreting the question, its temporal requirements and selecting candidate answers, (2) document processing, which includes indexation based on temporal information, finally (3) answer processing, where we start with the temporal inference before getting the answer.

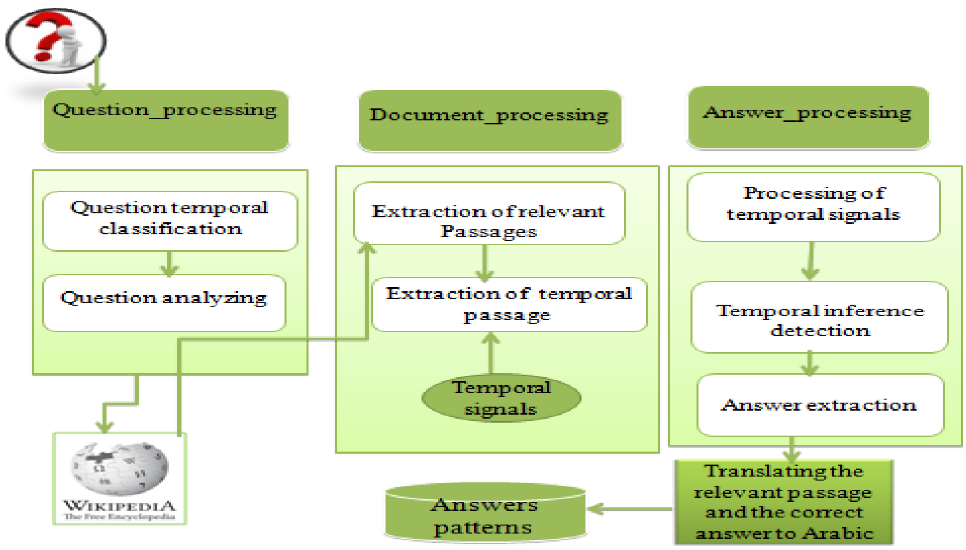

Fig. 1. Proposed approach

4.1 Question Processing

The objective of this process is to understand the asked question, for which analytical operations are performed for the representation and classification of the questions.

The first step of **question processing** is based on the classification of the questions referring to the temporal information extracted from the question. We have used the list of questions produced in TERQAS Workshop[1].

Some of the question classes are listed in Figure 2. This classification is based on the ways questions signal their time or event dependence and on how straightforward it is to determine the time at which information needs to be understood from a question so that will be possible to provide a suitable answer.

The classes of questions in Table 1, are characterized by the presence of a date and temporal signals, e.g. “since”, “after” and in some of them, we need to decompose the question to a temporal relation between events, indicated by a temporal signal.

Table 1. Classes of Temporal Questions

Question Class	Example
Time−Related	When was Moncef Marzouki president of Tunisia?
	How long did the Tunisian revolution last?
Event−Related	What must happen before the {Christmas} feast can begin in Poland?
Temporal−Order	Did John Sununu resign before or after George Bush’s ratings began to fall?
Entity− Related	How old was Mondela when he died?

We have experimented in a **first time** this classification using a set of 100 temporal questions and a set 100 associated answers extracted from temporal passages. The obtained results are very encouraging: **80%** of the temporal information selected from the suitable answer which contains the temporal information already expected from the question classification, **13%** to the unexpected answers (not correspond with the classification) and **7%** to the unfounded answers. In **second time**, we expand the number of questions; the results are shown in Table 2.

Some attempts were made to reach a better question analysis in the question answering task. Most of these attempts focused on keyword extraction from the user's question [13] made some query formulation and extracted the expected answer type, question focus, and important question keywords. To perform a better question analysis, the research of [14] analyzed questions by eliminating stop words, extracting named entities and classified the questions into Name, Date, Quantity, and Definition questions according to the question word used.

Table 2. Experiment results

Number of questions	Suitable answers
100	80
200	172
400	365

[1] TERQAS was an ARDA Workshop focusing on Temporal and Event Recognition for Question Answering Systems, www.cs.brandeis.edu/_jamesp/arda/time/readings.html

The research of [15] made some query formulation and extracted the expected answer type, question focus, and important question keywords. The question focus is the main noun phrase of the question that the user wants to ask about. For example, if the user's query is "What is the capital of Tunisia?" then the question focus is "Tunisia" and the keyword "capital" and the expected answer type is a named entity for a location. In our proposal, the step of analyzing the question is based on the elimination of stop words, extraction of the name entities and on the question classification.

4.2 Document processing

Extraction of the relevant document. QA systems benefit from keywords to quickly and easily find the relevant passages. All the documents are indexed with all these forms of information that enable the retrieval of the candidate's text passages.

Extraction of the relevant passage. Passages that do not contain time stamps or do not comply with the temporal relations that are searched are filtered out. Event recognition and classification as well as temporal expressions have been pointed out to be very important for our approach. TimeML [16] is a corpus annotated with: (a) time expressions; (b) events and (c) links between them. These annotations enable several forms of temporal inference [16] [17] [18]. The temporal information processing includes extracting events (TimeML EVENT tag), temporal expressions (TimeML TIMEX) and identifying temporal relations (TimeML TLINK tag).

The step of temporal passage retrieval has allowed only passages that contained at least one absolute or relative time expression. It also captures the event temporal orderings of the predicates and their relations to the answer structures.

4.3 Answer Processing

This module is responsible for selecting the response based on the relevant fragments of the documents. To be able to answer time-related questions, a question answering system has to know when specific events took place. For this purpose, temporal information can be associated with extracted facts from text documents [19].

Temporal inference. Either time expressions or events are related but are sometimes ambiguous. For example, the question Q: "how long did the Tunisian revolution last?" is classified to ask about a Time−Related, due to the presence of the question stem "how long".

```
The Jasmine Revolution   began on 18 December 2010 and led to the oust-
ing of longtime president Zine El Abidine Ben Ali finally in 14 January
2011. Following the events, a state of emergency was declared.
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The answer that is inferred from this paragraph is "18 December 2010 –14 January 2011".

In Q, the event of the "Tunisian revolution" can be paraphrased by the "The Jasmine Revolution" expressed in the first sentence of the paragraph. The same mining is referred to the underlined expression "The events".

The first reference (***The Jasmine Revolution began on 18 December 2010***) indicates a relation of **INITIATION** between the event ***«The Jasmine Revolution"*** and the fully specified temporal expression ***"18 December 2010"*** strengthened by the adverb "***began***". The second reference has an aspectual relation of **TERMINATION**, which is strengthened by the adverb "***finally***".

The final inference enables the recognition of duration of an event when a time expression is identified for its initiation and for its termination. The correct answer is 27 days. The Automatic Translation provided by Wikipedia allows us to have by a simple and a quick projection to translate the pertinent passage and the right answer already found to Arabic. Such answers are important in Arabic QA system as they can be used to provide an answer from a document collection. We therefore decided to investigate the potential of those answers by acquiring patterns automatically

5 Answers patterns

It has been noted in several QA systems that certain types of answer are expressed using regular forms [20] [21]. For example, for temporal question like BIRTHDATEs (with questions like "When was X born?"/ متى ولد فلان؟), typical answers are:

```
Mozart was born in 1756.
  Gandhi (1869-1948)
 These examples suggest
 pattern like
  <NAME> was born in <BIRTHDATE>
  <NAME> <BIRTHDATE>-
```

```
ولد موزارت في سنة 1756
غاندي (1869 -1948)
These examples suggest pattern
like
<إسم> ولد في سنة <تاريخ ميلاد>
<إسم><تاريخ ميلاد>-
```

When formulated as regular expressions, they can be used to locate the correct answer. Patterns are then automatically extracted from the returned documents and standardized to be then applied to find answers to new questions from a document collection. The precision of the patterns is calculated by cross-checking the patterns across various examples of the same type. This step will help to eliminate dubious patterns.

6 Conclusion

One of the most crucial problems in any Natural Language Processing (NLP) task is the representation of time. This includes applications such as Information Retrieval techniques (IR), Information Extraction (IE) and Question/answering systems (QA). This paper deals with temporal information involving several forms of inference in Arabic language. We introduced a methodology to compute temporal inference for QA that enables us to enhance the recognition of the exact answers to a variety of questions about time. We have argued that answering questions about temporal information requires several different forms of inferences, including inferences that derive from relations between events and their arguments.

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