Semantic based Query Expansion for Arabic Question Answering Systems

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***Abstract*— Question Answering Systems have emerged as a good alternative to search engines where they produce the desired information in a very precise way in the real time. However, one serious concern with the Question Answering system is that despite having answers of the questions in the knowledge base, they are not able to retrieve the answer due to mismatch between the words used by users and content creators. There has been a lot of research in the field of English and some European language Question Answering Systems to handle this issue. However, Arabic Question Answering Systems could not match the pace due to some inherent difficulties with the language itself as well as due to lack of tools available to assist the researchers. In this paper, we are presenting a method to add semantically equivalent keywords in the questions by using semantic resources. The experiments suggest that the proposed research can deliver highly accurate answers for Arabic questions.**

***Keywords*— Arabic Question Answering Systems; Query Expansion; Arabic WordNet**

I. INTRODUCTION

Today, the Web has become the chief source of information for everyone from a general user to the experts, the students to the researchers, to fulfill their domain needs. However, the Web contains huge amount of information, and sometimes, specific answers are needed for asked queries. Search engines like Google help the users to find the relevant information based on the keyword searching. The user spends more time to search the list of retrieved web documents to find related answers. In many cases, none of the retrieved web pages contains the relevant answer of the user's question. Secondly, a typical user always prefers the answers in few sentences instead of an entire document. Due to all these reasons, researchers came up with a revolutionary idea of introducing Question Answering System as an alternative solution.

A typical Question Answering System, as shown in Fig 1, follows a pipeline architecture. It consists of three main modules: Question analysis, Document analysis, and Answer analysis. The questions flow from the first module "Question Analysis" to the end module, which is the answer module. Modules are sequenced in a way that the output of each module is an input to the next module [1] [2].

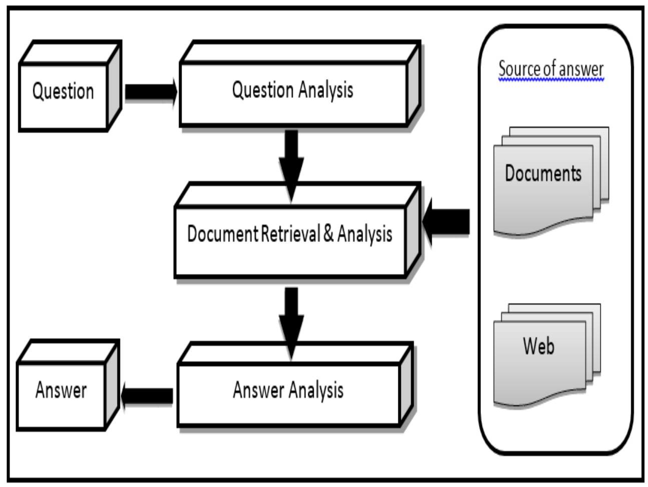

Figure 1 General architecture of a Question Answering System

The question analysis module takes natural language question as input, specifies what the question is asking for, like location, date, person's name etc., and is responsible for analyzing the question completely. The main aim of question analysis is to understand the question purpose and meaning. To understand the question purpose, the question should be analyzed in different ways. Firstly, carry out the words' morpho-syntactic analysis of the question. This is done by tagging each word in the question by their part of speech (POS). After POS tagging of the words, it is beneficial to find out the questioning information (what the question looking for). A question class helps the system to classify the question type to provide a suitable answer; this might need more clarification from the user [3]. To understand the Arabic language question, Question Answering Systems needs special handling [4]. This is because most of Arabic words has been built from three or four roots of letters [5]. The derivations of these words are shaped by adding the affixes (infix, prefix, and suffix) to each root depending on around 120 patterns [6].

To get the meaning of the question, we need to classify the question semantic type, which is an important step to get the actual answer. Question classification means to classify the

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question into pre-defined semantic categories; this leads to consider different strategies of processing. Question classification process is used to generate possible question classes. For example, a question can seek for date, time, location, or person. For instance, if system is able to understand the question "Who was the first American in space?" expecting that the person name is in the answer, the search space of reasonable answers will be definitely reduced.

In general, almost all Question Answering Systems involved a question classification module. The precision of question classification is very significant to the performance of the Question Answering System. Sometimes the question keywords are enough to determine the expected answer types. However, in many cases the question words are not enough, like "which" and "what" do not include that much semantic information. Questions seeking for entity types like "Which road ...?" or "What industry …?" are easy to determine. For other questions that includes constructions of more syntactically complex like "What was the first president of United States?" or "When was the first World Cup?", determining the question types is difficult. Most of the systems include comprehensive analysis of the question in order to apply more restrictions on the answer entity. For instance, identify the question's keywords that help in matching the sentences containing candidate answers [25]. Moreover, finding relations, syntactic, and semantic that must be hold between the entity of candidate answer and additional entities stated in the question is also helpful [7].

Once the question type being sought has been recognized, the remaining task in question analysis is to recognize more constraints that the questions description type must meet as well. This process is simple as taking out the keywords from the remaining of the question to be used in finding the candidate answer sentences. These keywords may then be extended by using morphological and/or synonyms replacements [8] or using query expansion techniques. For instance, delivering a query that is based on the keywords from an encyclopedia and using the top ranked passages retrieved to extend the keyword set [9] .

Whatever the kind of question answering architecture is selected; answering a question includes some type of searching for retrieving documents that involves the answer [10]. This module depends on the identification of the subset components of the retrieval system, which includes terms of assumed query from the collection of the total documents. The retrieval system returns the most likely documents that contain the answer within a ranked list to be analyzed by the next module Answer analysis [11].

The document analysis module takes the most likely answer list with the question classification description that shows what answer should be. This specification used to generate a number of answers, which are closely related to the question to be sent to the answer analysis module. This module selects the most correct answers among the phrases of certain type given by the question analysis [12]. The nominated answers, which are chosen from the ranked documents in terms of the most correct answers, are reverted to the user by this module [13].

The final component in the general architecture of Question Answering System is the representation of the user answer from the selected documents that includes the answer. The system that analyzes the question to get an expected answer follows some procedures to analyze the contents of the documents. These procedures can be done via the matching process, which requires the text unit from the user answer text (in case splitting the sentence has been achieved) includes a string that its semantic type matches the expected answer [14].

As discussed earlier, a user enters a query into an information retrieval system and expects answers retrieved from relevant documents. The information retrieval system, in turn, identifies some of the key concepts present in the user query, and then adds variants for the key concepts, which permit the information retrieval system to look for the documents that contain relevant information. This procedure faces two difficulties: first, the user usually provides the system a small number of keywords, which are inadequate to distinguish between relevant and non-relevant information [15]. The second difficulty is the gap between the lexicon of the content creator and that of the users [1]. The authors of the documents may use a different lexicon to create documents on the web where users usually try to search for terms different from those used by authors, which leads to failure in matching the retrieval. Furthermore, there is no clear mechanism in the traditional information retrieval system that specifies the user requirements while using the search query. For example; if the user enters a question "من قتل جون؟" (Who killed John?), the traditional retrieval system will return information about who killed John Kennedy the president of United States and information about who killed John Lennon, as well as information about other famous people with name "John" [15].

From the above discussion, it is clear that one or two terms are not enough for search engines to retrieve accurate and relevant information. This creates the need for query expansion. Query expansion can add semantically equivalent terms to the original and thus enhancing the possibility of adding more documents containing relevant information. Modern information retrieval system include query expansion as a necessary module to reduce the gap between the semantic and syntax of the question [15]. This paper focuses on this particular problem of Question Answering Systems.

The remaining of the paper is organized as follow. Section II of this paper describes the research work related to different components of Question Answering Systems in general and query expansion in particular. Section III presents a query expansion algorithm to expand Arabic questions. In this algorithm, we have used Arabic WordNet (AWN) browser as an ontological resource. Section IV describes the methods with examples and presents the results of the experiment. Finally, section V concludes the paper and presents the future scope.

II. RELATED WORK

The research literature provides a large number of proposals for query expansion. All of these proposals for query expansion can be classified into three different categories: Manual, Automatic and Interactive. Manual query expansion is mostly connected with Boolean Online Searching. Manual query expansion is performed by selecting the terms of the query for expansion manually and interpreting the topic of the query using thesaurus such as WordNet synsets [16].

The relative usefulness of information retrieval systems is mainly affected by the fact that user queries general consist of a few keywords needed for the real user information. One of the well-known ways to get the better of this restriction is automatic query expansion [17], where original query of the user is enhanced by new words with a similar meaning. Automatic query expansion is responsible of increasing the initial or succeeding queries depending on certain methodology (uses numerous approaches classified into two main faces; Probabilistic and Ontological [17] [18] [19]. In interactive query expansion, both user and the information retrieval system are responsible for specifying and choosing terms required by the query expansion. This can be done by two steps; first the retrieval system use to choose, retrieve and then rank the terms of an expansion. Secondly, the user should decide which helpful terms are required for the query from the terms ranked list [17].The expansion terms can be selected from the input corpus or may be selected according to the external input corpus source like ontology or thesaurus [17].

Probabilistic query expansion usually depends on calculating the number of terms occurrence in the documents and choose the most likely terms related to the query. It can further be categorized into two main classes; global and local methods [20]. Global methods are techniques use to apply corpus-wide statistics to produce a list of nominee terms, which will be used to expand the query most alike to the query terms. The analysis of the global techniques shows that it is solid, but it includes heavy resources according to the calculations of the terms' similarity which usually is implemented off line. One of the primary fruitful analysis techniques is the clustering [21] that is grouping the document terms into clusters according to the suggested hypothesis. Queries are expanded by using this hypothesis which clusters the document terms depending on their number of occurrence in the same cluster.

On the other hand, Local methods techniques known as "relevance feedback" [22] refer to the process of interaction which assists to develop the retrieval performance. That means, the Information Retrieval System (IRS) returns the prior set of documents' results after the user query submission. Then IRS would ask the user to judge the relevant documents. Continually, the query would reformulated by IRS according to the user's decisions and returns set of new results. These techniques make Local methods faster than Global one [22]. There are normally three types of relevance feedback; 1) explicit, 2) pseudo, and 3) implicit. In case no relevance decision found, the pseudo relevance feedback may be implemented by taking a few number of results (top ranked documents) appearing at the prior retrieval and assuming them as relevant to initialize relevance feedback. In parallel, between pseudo relevance feedback and relevance feedback we can find implicit feedback, in which the user's information requirement can be deduced by interacting with the system [22].

Ontology browsing is a well-known automatic query expansion technique [17]. Knowledge prototypes such as ontologies and thesauri deliver an income for rephrasing in context the user's query. On the other hand, [14] suggested query expansion could be done using the category structures of Wikipedia. The query works according to the Wikipedia gathering and each category is allocated a weight relative to the number of outranked articles allocated to it. Then articles re-ranked documents depending on the accumulation of weights' categories to each belonging.

Once the candidate documents or passages are selected to get the answer, these may further need to be analyzed. At this stage, many of ways for document analysis needs to be considered, such as part-of-speech, splitting into sentences, and chunk parsing (recognizing some prepositional phrases, verb groups, noun groups, etc.). To organize a clear link between a phrase of a particular type and the question, several techniques such as the pattern matching, syntactic structure, linear proximity, and lexical chaining are used [24]. Ferret et al. [12] proposed a Question Answering System, which depends on shallow syntactic analysis to recognize multiword terms with their alternatives in the documents. These documents were selected to be re-ranked and re-indexed before the matching process against the representation of the question.

Harabagiu et al. [26] use an extensive coverage statistical parser trained on the Penn Treebank to construct a reliable representation of the sentence in the answer documents. After that, they match this reliance representation to be in the first logical order of the representation. Hovy et al. [27] also used the parser trained on the Penn Treebank, but they considered generating a structure tree of syntactical oriented phrase. After that, they match this into a representation of a logical form.

Like previous components, there are several ways to choose or rank the retrieved answers. Moldovan et al. [28] used an approach in which once the answer expression is found in the user answer paragraph, a window of the answer sentences is created. Different features like computing the whole score answer window through the word overlap between the answer window and the question used to be applied. For each user answer paragraph that includes the correct answer expression, a score has to be derived for the answer window including the correct type. This score use to be considered for ranking overall user answers. Harabagiu et al. [26] added to this approach an extension by applying machine-learning algorithm to enhance the masses in the linear scoring function, which joins the features that characterizes the answer window.

Srihari et al. [8] changed the order of the general approach by reversing it. This has been done by applying the question constraints more than the type of the expected answer as a filter to excerpt the suitable portion of the chosen sentences. On other side, they used for ranking the sentence features like the number of unique keywords found in the sentence. The keywords order in the sentence used to be a comparison to their order in the question, and find out whether the keyword is verb or irregular matches.

Ittycheriah et al. [9] have combined predictable answer type matching with a set of word based comparison methods in one scoring function. They implemented this function on three sentences windows extracted from user answer documents. Light et al. [29] delivered a discussion related to upper bounds on the comparison of word based approaches. Moreover, the frequency of user answer found to be measured as a standard for answer analysis and selection. This frequency represents the number of happenings linked to the question, and it is also called redundancy answer selection [30]. This can be expanded to a larger set by counting the number of frequencies related to the set of documents that was delivered in the document analysis component [13]. Some Question Answering Systems count the number of answers occurs in terms of the question from the whole document collection. Others go beyond the document collection by using the World Wide Web to catch the frequencies [31].

III. Proposed Query Expansion Methodology

As described in the previous section, there are two main approaches for query expansion: Manual and Automatic. In this section, we are proposing a manual query expansion approach for Arabic Question Answering Systems. The proposed query expansion algorithm uses an ontological resource to find the semantically equivalent words. The detail of the algorithm is as follow:

Input: *A user query (Q)*

Output: *A semantically enhanced query (QE)*

Step 1: *Extract the keywords C1, C2, …., Cm from the user query Q.*

Step 2: *For i= 1 to m*

Use Ontological resource to extract top n semantically equivalent terms for Keyword under consideration. For Keyword Ci, semantically equivalent words are Ci1, Ci2, …, Cin.

Step 3: *Construct a new Query using Boolean operators "AND" and "OR" as*

(C11 OR C12 OR… OR C1n) AND (C21 OR C22 OR… OR C2n) AND …. AND (Cm1 OR Cm2 OR… OR Cmn)

Step 4: *End*

Keywords are extracted from the user query (Q), and then the Ontology resource is looked for the top ten semantically equivalent terms for each of the keywords. Then Boolean operators "AND" and "OR" are applied to construct a new semantically equivalent search query.

To test the proposed algorithm, we selected 50 Arabic questions from a standard set of questions and answers, known as TREC & CLEF Arabic questions, developed by Y. Benajiba[1]. We tested the selected questions by using Google search engine. The results of each question have been taken according to the top ten ranked results. We compared each rank result with the answer mentioned in our selected database. A comparison result of each rank has been recorded in the next section.

In the second phase of testing, by using the same set of questions; a query expansion has been applied by taking each keyword of the question and find its synonyms using semantic resource Arabic WordNet (AWN) tool. In addition, the synonym of each word have been formalized in the question by using the "OR" logical operator, then the resulting query string has been tested using Google search engine. For instance, the question;

"ما هو المنصب الذي شغله ياسر عرفات" (What is the position that Yasser Arafat held?), this question has been expanded by using query expansion using AWN to;

" ما هو (المنصب أو الوظيفة أو المكانة أو المرتبة) الذي (تبوأه أو شغله أو عمله) ياسر عرفات"

Here "أو" indicate logical operator "OR" and "AND" operator is default concatenation operator. Then, we fed the modified queries into Google and retrieved top ten results for each query.

IV. Results

This section describes the results of the proposed query expansion algorithm. To analyze the impact of the proposed query expansion algorithm, we used a standard set of 150 Arabic questions and answers compiled by Y. Benajiba[2] from TREC and CLEF as dataset. These questions were first fed into Google search engine and top ten answers for each question were retrieved. These answers were analyzed in terms of numbers of correct answers. For instance; the question " من كان أول رئيس للولايات المتحدة الأمريكية ؟" (Who was the first President of the United States of America?), Google search engine gives six correct answers out of first ten answers. Moreover, another instance just like "ما هو العام الذي ألقيت فيه القنبلة الذرية على هيروشيما ؟" (What year the atomic bomb was dropped on Hiroshima?) shows three correct answers out of first ten answers.

The same sets of questions were then semantically enhanced using the proposed algorithm. The Arabic WordNet browser was used to find the semantically equivalent words. The Arabic WordNet (AWN) tool is a separate application that can be executed on any computer includes a Java virtual machine. It is a freely available tool to provide semantically equivalent words, which can be used in many information retrieval and NLP applications [32] [33]. To carry out the research proposed in this dissertation, we used AWN browser release 2.0 Beta version, developed by Informatics NLP Team[3]. This version of AWN uses different ontologies like English, Arabic, and SUMO, where each ontology type has its interface with distinct panel. Each panel can be distributed into three universal segments; an input segment, a gloss segment and a segment for the word tree beside any extra language-specific characteristics. The main motive of using AWN browser is to search for concepts that can be used to expand the user query.

In our system, we checked each word (verb) of the question using AWN, which includes 11269 synsets and 23481 Arabic words. The set of 50 expanded queries were fed into Google to retrieve the relevant answers. These answers were also analyzed in terms of numbers of correct answers. For instance;

"من كان (أول أو الأول) (رئيس أو زعيم) للولايات المتحدة الأمريكية ؟ "

1 http://users.dsic.upv.es/~ybenajiba/

2 http://users.dsic.upv.es/~ybenajiba/

3 http://globalwordnet.org/arabic-wordnet/awn-browser/

The results show ten correct answers out of top ten answers after applying the query expansion. Moreover, another instance like;

"ما هو (العام أو الحول أو السنة) الذي ألقيت فيه القنبلة الذرية على هيروشيما ؟"

The results show nine correct answers out of top ten answers. The query expansion results as shown in the Figure 2 indicate that query expansion has positive impact on the number of correct answers retrieved by the search engine. The average of correct answers per question we received before query expansion is 4.5 while it is 6.7 after query expansion.

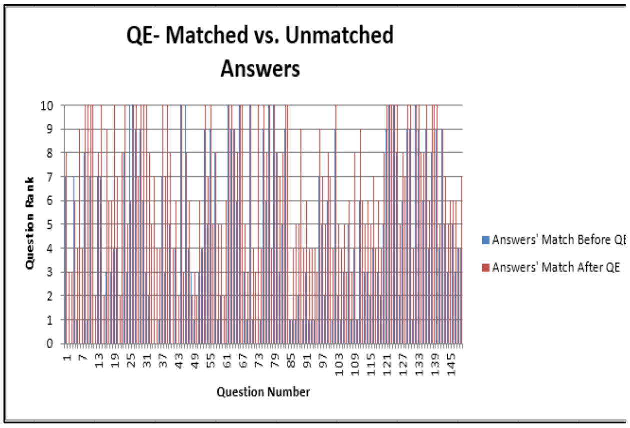

Figure2: Questions summary (Matched vs. Unmatched answers)

Mean Reciprocal Ratio (MRR) indicates how well the information retrieval systems are ranking the retrieved documents. MRR for a question 'Q' can be defined as

MRR (Q) = $\sum_i 1/i$

Where i is the rank of the correct answer. For example, if the correct answers for a question is found in documents ranked 2,4 and 8, then MRR will be ½+1/4+1/8 = 0.875. We analyzed the results of the query expansion using MRR also as shown in Figure 3.

The rank of MMR values varies from 0.0 to 3.0 for the questions under consideration in both cases, before and after applying query expansion. We can notice in general that the MRR values before query expansion fluctuated from 0 to 2.9, while some results gives good results especially questions 13 to 19 and 41 to 46.

The MRR average of correct answers per question we received before query expansion is 1.53 while it is 2.18 after query expansion.

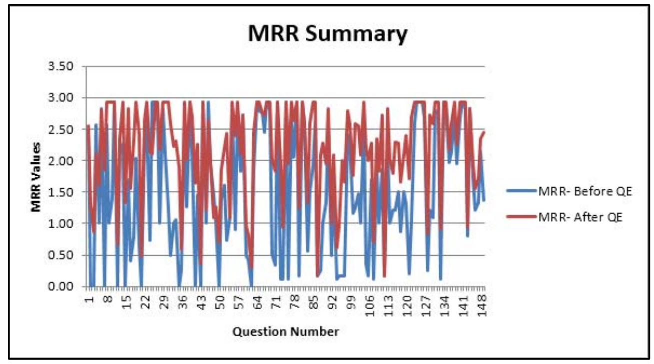

Figure 3: MRR Summary towards using query expansion

V. CONCLUSION AND FUTURE WORK

Question Answering Systems have been emerged as major source of information retrieval. In this paper, we described the architecture of a typical Question Answering System. Question analysis is the first and very crucial component of a Question Answering System. As it affects the overall performance of a Question Answering system, very high accuracy is required in question processing phase. Besides processing the question syntactically, it is important to add semantically equivalent keywords in the question to reduce the gap between the keywords used by users and the content creators. Arabic Question Answering Systems lack effective processing of questions. In this paper, we attempted this aspect and proposed a method to add keywords using semantic tools.

This work can be extended to improve the AWN and study the applicability of improved version of AWN. We focused only on designing and developing Question Analysis module of Arabic Question Answering Systems. As a future work, same can be applied for the other two phases of Question Answering Systems. In Document analysis, we can look for such methods used in information retrieval including tools, evaluation, and corpus.

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