

Improving the Accuracy of English-Arabic Statistical Sentence Alignment

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Abstract: Multilingual natural language processing systems are increasingly relying on parallel corpus to ameliorate their output. Parallel corpora constitute the basic block for training a statistical natural language processing system and creating translation and language models. Several systems have been devised that automatically align words of a pair of sentences, each in a language. Such systems have been used successfully with European languages. In this paper, one such system is used to align sentences in an English-Arabic corpus. The system works poorly given raw unaligned sentence English-Arabic sentence pairs. This prompted the development of a preprocessing step to be applied to the Arabic sentences. The same corpus was then preprocessed and a significant improvement is reported when alignment is attempted using the preprocessed unaligned sentences.

Keywords: Word alignment, sentence alignment, parallel corpora, and statistical natural language processing.

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1. Introduction

Computing research and applications for the Arabic language has recently increased. This is due mainly to the increase in the number of Arab internet users who do not master other languages [7]. Another reason for the interest in Arabic is non-Arab (usually European and American) interest in Arab countries. Arabic is more difficult to treat compared to European languages mainly because of its rich morphology.

There are many difficulties for machine treatment of Arabic text compared to treating English text [5]. First, a single word in Arabic can have many variations depending on the morphological variations that it can undertake. Like English, Arabic adds prefixes and suffixes to a word to form other variants. However, unlike English, Arabic can also add infixes to words. This makes algorithms for English morphological analysis not applicable to Arabic. Second, the prefixes and suffixes of a word may not always be attached to the other letters in the same word. Third, in Arabic a whole English sentence can be represented using one single word (e.g., "Should we then force it upon you" is translated to "أفعلنز مكموها"). Fourth, unlike English, the prepositions and pronouns are not separate words. Prepositions and pronouns in Arabic are usually attached to the word (for example, the 2-word English phrase "his book" is translated to a single word "كتابه" in Arabic). Fifth, a single English word can have a multiword Arabic translation (e.g., "غير مزود بالسلاح" is translated to "unarmed"). Sixth, spaces, in Arabic, might not separate two words from each other. For example, the conjunction و is usually written without a

space between it and the next word. Seventh, the word order in an Arabic sentence is usually different from that in the English sentence. In fact, the word order might change in different Arabic translations of the same English sentence. For example, the sentence "The boy went to school" can be translated into "ذهب الولد الى المدرسة" or "الى المدرسة ذهب الولد" or even to "الولد ذهب الى المدرسة". Eighth, Arabic sentences might not contain any verbs.

Recently, Natural Language Processing (NLP) systems in general and Machine Translation (MT) systems in particular have improved their output quality by resorting to statistical techniques. A prerequisite for the use of any statistical technique is the availability of appropriate data. For example, Statistical Machine Translation (SMT) systems require the existence of a Language Model (LM) and a Translation Model (TM). Such models are usually built by automatic processing of multilingual corpora. Multilingual corpora are a large number of texts translated to all languages supported by the corpus. Before such corpora can be used, they have to be aligned so that a word in the text in one language is linked to the corresponding word in the text of the other language. Several systems exist that can do the alignment automatically by processing a large unaligned corpus. One such system is the GIZA++ system [13] that has been proven to work well for corpora of parallel European languages texts.

In this paper, we review related literature in section 2. The results of trying to use GIZA++ directly on an English-Arabic corpus are reported in Section 3. These results show that GIZA++ does not work well when

raw Arabic text is used. The complexity of the Arabic language is proven to be an obstacle for statistical automatic sentence aligners like GIZA++. In Section 4, a solution is detailed that improves the performance of GIZA++. In this solution, the Arabic and English texts are preprocessed before being handled by GIZA++. Guidelines for preprocessing the Arabic part of the multilingual corpus are presented and proven to ameliorate the automatic alignment process. In Section 5, the paper is concluded with a summary of the achievements and suggestions for future research.

2. Better Alignment in Literature

Alignment of multilingual corpora is usually divided up into sentence alignment and word alignment. Sentence alignment identifies correspondences between sentences in one language and sentences in another language. The basic units for segmenting parallel texts in sentence alignment are paragraphs and sentences. It is usually assumed that both parallel texts have the same number of paragraphs. Sentences inside paragraphs do not necessarily have a one-to-one alignment in a multilingual corpus. A sentence in a source language might be translated into 2 or more sentences in the target language. Similarly 2 or more source language sentences might be translated into a single target language sentences. Several clues in a text can aid in aligning parallel texts such as titles (including chapter, section, table and figure titles), cells inside a table, and items of an enumeration (items usually listed each on a separate line). Sentence alignment techniques vary from length based models to lexical based models or a combination. Length based techniques mainly rely on comparing the length of the sentences and therefore are considered knowledge poor [1]. Such approaches achieve high accuracy for many European languages [3]. Length based approaches that use the numbers of Characters in a sentence were proven to work better than those that use the number of words [2, 3]. Lexical based methods are considered knowledge-rich [10]. Anchor words are chosen from the pair and checked whether they correspond to each other. One of the methods relies on calculating the probability of word pairs by checking the frequency of words in the source sentence and trying to find how many words in the target sentence correspond to their translations. Another method is to find chains of corresponding vectors after mapping the text into a two dimensional space [10]. Combinations of length-based and lexical-based sentence alignment techniques exist [15]. String similarity measures and machine readable dictionaries can be used to enhance the sentence alignment. Word frequencies and occurrences are checked to achieve good results. K-vec is one of the approaches where sentence pairs are split into equal segments and parallel segments are checked if they have words with similar meanings [9].

Word alignment is the process of linking corresponding words and phrases in a parallel text. The aim is to extract the maximum number of corresponding sets from the parallel text that can be used in a desired application. Factors that affect word alignment are Structural, lexical, and grammatical differences between the languages; morphological differences between languages; and spelling errors inside the parallel text. Word alignment techniques are divided into two groups: the Association approaches and the Estimation approaches. Association approaches use heuristics to perform the word alignment [12] while Estimation approaches use statistical rules [9]. Preprocessing to ameliorate SMT quality has been proven to be effective for morphologically rich languages such as German [11], Spanish, Catalan, and Serbian [14], and Czech [4]. As far as Arabic is concerned [8] and [6] showed that morphological preprocessing helps only in the case of small corpora. Using GIZA++ without preprocessing.

3. Properties of the Corpus Used

The corpus used in this paper was collected from the UN documents and resolutions of the past ten years. It contains 2154 English-Arabic sentence pairs whose properties are shown in Table 1.

Most of the used terms are related to the political and geographical context of the countries that the resolutions were addressing (Palestine, Lebanon, Syria, Iraq, Afghanistan, and African countries). The documents contain many political terms and named entities (names of places, political figures, months, and chemicals). In addition, the sentences in the documents contain many abbreviations for names of UN projects, offices and other entities that are translated into meaningful complete Arabic phrases in the Arabic version of the texts.

Table 1. Properties of used corpus.

Number of Pairs	2154
Maximum Number of Words in an English Sentence	132
Maximum Number of Words in an Arabic Sentence	175
Maximum Ratio of English to Arabic Sentence	1.5
Minimum Ratio of English to Arabic Words	0.291
Average Ratio of English to Arabic Words	0.706

For example: "UNMOVIC" in English is translated to "الجنة الامم المتحدة للرصد والتحقق والتفتيش" in Arabic. In the corpus, a small number of the English sentences were translated to more than one Arabic sentence. Those sentences were either split if it was proper to do so or ignored. The sentences in the corpus were prepared for GIZA++ by transforming them into English-Arabic parallel sentences in an XML file. The

The suffixes in Arabic words that were identified in this paper were separated into two level suffixes:

- 1st level suffixes:
 - 1-letter Suffixes: "ة", "ي", "ه", "ت", "ا", "ن", "ك".
 - 2-letter Suffixes: "تن", "كم", "هن", "نا", "يا", "ها", "هم", "ما", "ني", "كن", "تم".
- 2nd level suffixes: if the root of the word is a verb then separate the suffix (either "ان", "ون", "ين" or "وا") from the verb by a space.
- If the root of the word is a noun then separate the suffix (either "ان", "ون", "ين" or "ات") from the noun by a space. As a special case, some nouns end in Alef Al-Tanween, in this case remove Alef Al-Tanween.
- If the root of the word is a relative adjective or a noun in their feminine form then separate the "ة" from the Adjective by a space.

As an example, after performing the split on the Arabic words, a sentence like: لكل إنسان الحق، على قدم المساواة التامة مع الآخرين، في أن تنتظر قضيته أمام محكمة مستقلة نزيهة نظراً عادلاً علنياً للفصل في حقوقه والتزاماته وأية تهمة جنائية توجه إليه becomes ل كل إنسان ال حق ، على قدم ال مساواة ال تام ة مع ال آخر ين ، في ان تنتظر قضية ه امام محكمة مستقل ة نزيه ة نظر عادل علني لل فصل في حقوق ه و التزام ات ه و اي ة تهمة جنائي ة توجه إلى ه

In the sentence level processing phase, three elements are added to each <sentence> node namely, <EnLen>, <ArLen>, <Ratio> as shown in Figure 4. The <EnLen> and <ArLen> fields contain the number of words in the English and Arabic sentences respectively. A "word" in this paper is the set of characters that are preceded and followed by a space. <Ratio> is the <EnLen> divided by <ArLen> and is used to decide whether the split position for a long sentence is good.

```
<sentence>
<ID>54</ID>
<En>It should be noted that , during the second terrorist attack near the
  Canal Hotel on 22 September , two UNMOVIC local staff were
  injured</En>
<Ar>اصيب قد ين محلي ال لجنة ال بن موظف من اثنين ان ملاحظة ال ب جدير ال من و
  </Ar> ايلول 22 في قناة ال فندق قرب وقع الذي ثاني ال ارهلي ال هجوم ال خلال
<EnLen>25</EnLen>
<ArLen>36</ArLen>
<Ratio>0.6944444444444444</Ratio>
</sentence>
```

Figure 4. Updated sentence node.

The choice of the stop words in English and Arabic languages is important. Three criteria were manually used to decide whether an English-Arabic pair is a stopword. First, a stopword should appear frequently in the text. Second, an English stopword should have an Arabic translation that is also an Arabic stopword.

Third, splitting English and Arabic sentence pairs at their stopwords should produce sentence pairs that have a high correspondence between their words.

After analyzing the commonly used English stopwords in the literature, several conclusions were attained. First, each English stop word has more than one translation in Arabic. For Example: "in order" is translated to "من اجل", "حتى", "بغية" and "ذلك ل". Second, many English stop words have the same translation in Arabic. For example, "within" and "during" are both translated to "خلال". Third, the same Arabic stopword (especially prepositions) can be the translation of many English stopwords. Fourth, some Arabic stopwords may not have any corresponding words in the English translation. Fifth, it is always easier to search for the stopwords in the English sentence first and then search for the corresponding stopword in the Arabic sentence. Sixth, possessive pronouns always precede the noun in English while they appear as suffixes that are attached to the noun in Arabic.

The preceding conclusions led to the exclusion of many English stopwords. Among the excluded stopwords are demonstrative pronouns (such as 'this', 'that', 'these', 'those'), indefinite Pronouns (such as 'anything', 'anybody', 'anyone', 'something', 'somebody', 'someone', 'nothing', 'nobody', 'none', 'no one'), possessive pronouns (such as 'mine', 'yours', 'his', 'hers', 'ours', 'theirs'), simple pronouns (such as 'I', 'you', 'he', 'she', 'it', 'we', 'they', 'me', 'him', 'her', 'us', 'them'), reflexive pronouns (such as 'self', 'myself', 'yourself', 'himself', 'herself', 'itself', 'oneself', 'ourselves', 'yourselves', 'themselves'), verb forms (such as 'am', 'are', 'is', 'was', 'were', 'be', 'being', 'been', 'has', 'have', 'had', 'having', 'can', 'could', 'want', 'wants', 'wanted', 'shall', 'should', 'will', 'would', 'may', 'might', 'must', 'ought', 'do', 'does', 'doing', 'did', 'done', 'make', 'makes', 'making'), coordinating conjunctions (such as 'and', 'but', 'or'), prepositions with very high frequency (such as 'under', 'from', 'in', 'by', 'for', 'upon', 'with', 'on', 'of', 'within', 'to' and 'at' which can be translated to the following arabic prepositions: 'ب', 'على', 'الى', 'في', 'من' and 'ل').

The stopwords that were used are the subordinating conjunctions shown in Table 2. Those stopwords achieve a fair split in English and Arabic sentences.

A split is considered successful if the ratio of the positions of the English stopword and its Arabic translation (Arabic stopword) is close to the ratio of word counts in both sentences (within a certain threshold value of 0.21 which was determined experimentally as a good value). Aside from using stopwords, punctuation marks (especially the comma) were also used to breakup long sentences. The split according to commas uses a threshold value of 0.12 (that also was determined experimentally).

Table 2. Stopwords used in the paper.

Particularly	لا سيما خاصة	including	بما في
Between	بين	in order	كفي أمن اجل احتي ابغية ذلك ل
Before	قبل	which	مما الذي التي
Therefore	لذلك ان	although	بالرغم على الرغم من
Though	رغم ان او ان	when	حين اقيما
If	حتى لو اذا	while	في حين ابينما في ما لا يزال
Because	نتيجة انظر لان	unless	ما لم
Whenever	حيثما كلما متى	but	لكن
Within	خلال ادخل	during	خلال اثناء
Across	عبر	under	تحت
According	طبق اوفق	prior	قبل اسابق
When	عندما عند ابعدم	accordance	على النحو اوفق اعمل
Especially	لا سيما خاصة	but also	بيد الا بل اذ
Rather	بدل		

Table 3 shows the results of successful splits. We can conclude from Table 3 that all English sentences have been transformed into ones that have less than 100 words. Table 4 shows that unsuccessful splits happened only with English sentences that have less than 100 words. This means that all English sentences that have more than 100 words have been split successfully.

Table 3. Successful splits.

Statistics about Sentences after Successful Split	
Maximum Number of Words in an English Sentence	91
Maximum Number of Words in an Arabic Sentence	147
Maximum Ratio of English to Arabic Words	2.5
Minimum Ratio of English to Arabic Words	0.26
Average Ratio of English to Arabic Words	0.738

The average ratio of English to Arabic words did not change drastically before and after the splits which means that the structure of the corpus was not changed by splitting. Around 13% of commas in English sentences either disappeared in Arabic translations or were replaced by conjunctions. After splitting, the 2154 pairs of English-Arabic sentences became 3636. GIZA++ was able to align 22.32% of the English words when the original text (without preprocessing) was used. With preprocessing, this percentage rose to about 45.72%. Before preprocessing 44.7% of the English words were not aligned to any Arabic words. This percentage dropped down to 20.9% after preprocessing. The words that were not correctly aligned even after preprocessing were the words that had a low frequency in our corpus. Table 5 gives an example of a sentence and its alignment before and

after preprocessing. Before preprocessing, 11 English words were aligned correctly while after preprocessing, 23 English words were aligned correctly.

Table 4. Unsuccessful splits.

Statistics about Sentences that were not Split	
Maximum Number of Words in an English Sentence	92
Maximum Number of Words in an Arabic Sentence	155
Maximum Ratio of English to Arabic Words	1.5
Minimum Ratio of English to Arabic Words	0.29
Average Ratio of English to Arabic Words	0.709

5. Conclusions and Future Work

In this paper, the aim was to prepare the English-Arabic corpus for correct processing by the alignment software. This was done by increasing the frequency of Arabic words through character and word level processing. Another step was to decrease the length of English-Arabic sentence pairs by splitting them into smaller phrases using stopwords and commas. These preprocessing steps resulted in a 100% improvement in alignment and number of unaligned words. Many aspects of the work presented in this paper can be explored further. First, an automatic way for choosing the best stopwords from English and Arabic text should be devised. It is our belief that the stopwords will be function of the type of text and therefore stopwords used in literary text might be different from stopwords used in newspaper articles. Second, new ways for reducing the sizes of sentences should be developed. Currently, we rely on stopwords and commas. It remains to be seen whether including all punctuation marks and morphological information might ameliorate the splitting of long sentences. Third, Arabic particles and prepositions around the words should be used to improve the alignment rather than considering those particles and prepositions as independent entities. Fourth, dictionary entries and/or morphological information should be used to check the alignment produced by GIZA++ or to suggest alignment to GIZA++. A word pair that was already aligned in previous runs should be used to better the alignment of future runs. Fifth, automating the preprocessing steps described in this paper will enable the use of larger corpora that are commensurate with the corpora used for European languages.

Table 5. Improvements due to preprocessing.

Without Pre-processing	<p># Sentence pair (340) source length 58 target length 47 alignment score : 8.04656e-73 وقد قررت المحكمة، بما لا يدع مجالاً للشك أن إسرائيل ملزمة بوضع حد لانتهاكاتهما للقانون الدولي، وبوقف تشييد الجدار الذي تبنيه في الأرض الفلسطينية المحتلة، بما فيها داخل القدس الشرقية وما حولها، وبتفكيك الهياكل المقامة في تلك المنطقة، وبإلغاء أو إبطال جميع القوانين التشريعية والتنظيمية المتصلة به</p> <p>NULL ({ 22 36 }) The ({ 1 }) Court ({ 2 }) has ({ }) determined ({ }) beyond ({ }) any ({ }) doubt ({ 3 4 5 6 7 8 }) that ({ 9 }) Israel ({ 10 }) is ({ }) under ({ }) obligation ({ }) to ({ }) terminate ({ }) its ({ }) breaches ({ }) of ({ }) international ({ }) law, ({ }) to ({ }) cease ({ }) the ({ }) construction ({ }) of ({ }) the ({ }) wall ({ 18 19 }) being ({ 20 }) built ({ 21 }) in ({ }) the ({ }) Occupied ({ 23 }) Palestinian ({ 24 }) Territory, ({ 25 }) including ({ 26 27 }) in ({ }) and ({ }) around ({ 28 }) East ({ }) Jerusalem, ({ 29 30 }) to ({ }) dismantle ({ }) the ({ }) structure ({ }) therein ({ }) situated ({ 11 12 13 14 15 16 17 31 32 }) and ({ }) to ({ }) repeal ({ 33 34 35 37 38 39 }) or ({ 40 }) render ({ }) ineffective ({ 41 }) all ({ 42 }) legislative ({ 43 44 }) and ({ }) regulatory ({ 45 46 }) acts ({ }) relating ({ }) thereto ({ 47 })</p>
With Preprocessing	<p># Sentence pair (746) source length 20 target length 27 alignment score : 7.59922e-42 قد قررت المحكمة، بما لا يدع مجالاً للشك أن إسرائيل ملزمة بوضع حد لانتهاكاتهما للقانون الدولي، وبوقف تشييد الجدار الذي تبنيه في الأرض الفلسطينية المحتلة، بما فيها داخل القدس الشرقية وما حولها، وبتفكيك الهياكل المقامة في تلك المنطقة، وبإلغاء أو إبطال جميع القوانين التشريعية والتنظيمية المتصلة به</p> <p>1 NULL ({ 4 16 22 25 }) the ({ }) court ({ 3 5 }) has ({ 1 }) determined ({ 2 }) beyond ({ 6 }) any ({ }) doubt ({ 7 8 9 10 11 12 }) that ({ 13 }) israel ({ 14 }) is ({ }) under ({ }) obligation ({ 15 }) to ({ }) terminate ({ 17 18 }) its ({ }) breaches ({ 19 20 21 23 }) of ({ }) international ({ 26 }) law ({ 24 }), ({ 27 })</p> <p># Sentence pair (749) source length 6 target length 12 alignment score : 3.14924e-18 ها داخل القدس الشرقية وما حولها،</p> <p>2 NULL ({ 3 5 7 8 }) in ({ }) and ({ }) around ({ 1 2 9 10 11 }) east ({ }) jerusalem ({ 4 6 }), ({ 12 })</p> <p># Sentence pair (747) source length 15 target length 18 alignment score : 8.35513e-23 وبوقف تشييد الجدار الذي تبنيه في الأرض الفلسطينية المحتلة،</p> <p>3 NULL ({ 1 2 5 10 12 15 }) to ({ }) cease ({ 3 }) the ({ }) construction ({ 4 6 }) of ({ }) the ({ }) wall ({ }) being ({ }) built ({ 7 8 }) in ({ 9 }) the ({ }) occupied ({ 11 13 14 16 17 }) palestinian ({ }) territory ({ }), ({ 18 })</p> <p># Sentence pair (750) source length 19 target length 30 alignment score : 1.25909e-38 و بتفكيك الهياكل المقامة في تلك المنطقة، وبإلغاء أو إبطال جميع القوانين التشريعية والتنظيمية المتصلة به</p> <p>4 NULL ({ 1 3 5 7 9 18 20 26 }) to ({ }) dismantle ({ }) the ({ }) structure ({ }) therein ({ 2 4 6 }) situated ({ 8 10 11 }) and ({ 12 }) to ({ }) repeal ({ 13 14 }) or ({ 15 }) render ({ }) ineffective ({ 16 19 }) all ({ 17 }) legislative ({ 21 22 }) and ({ 23 }) regulatory ({ }) acts ({ }) relating ({ }) thereto ({ 24 25 27 28 29 30 })</p>

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