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Arabic to English Machine Translation

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Abstract

Transfer-based technique is currently one of the most widely used methods of machine translation. The idea behind this method is to have an intermediate representation that captures the meaning of the original sentence in order to generate the correct translation. In this paper we have explored several features of Arabic pertinent to MT. The hypothesis under investigation and main aims of this paper are to build a robust lexical Machine Translation (MT) system that will accept Arabic source sentences (SL) and generate English sentences as a target language (TL), and to examine how the challenges imposed by this particular language pair are tackled. The paper represents as well a starting point for the future implementation of a successful Arabic MT engine. The conducted experiment proves that our system (AE-TBMT) has scored the highest percentage by 96.6 percent; this means that only three percent of the entire test examples have not been handled correctly, and this result is considered fair if not good, as the other three systems score below that mark.

Keywords: Machine Translation; Transfer-based approach; Arabic Natural Language Processing, AE-TBMT.

1. INTRODUCTION

Arabic is a Semitic language spoken by more than 330 million people as a native language extending from the Arabian Gulf in the East to the Atlantic Ocean in the West. Moreover, it is the language in which 1.4 billion Muslims around the world perform their daily prayers [1]. At the level of morphology, Arabic is a templatic, inflectional and derivational language [2-5]. At the level of syntax, Arabic is considered as a subject pro- drop language That is, every inflection in a verb paradigm is specified uniquely and need not to use independent pronouns to differentiate the person, number, and gender of the verb. Arabic words are often ambiguous in their morphological analysis [6]. As a natural language, Arabic is rich in morphological and syntactic structures. Arabic is also challenging in that it is a derivational or constructional language rather than a concatenative one. Arabic has relatively free world order, mainly, nominal Sentence Subject-Verb-Object (SVO) and Verbal Sentence Verb-Subject-Object (VSO). However, the default sentence structure is (SVO). The version of Arabic we consider in this paper is Modern Standard Arabic (MSA).

According to [7], Arabic Language has several distinguishing features that help in the translation process, the list below shows some of these features:

1. Arabic is written from right to left in a horizontal form.
2. Arabic writing sits on the line.
3. There are no capital letters in Arabic.
4. Punctuation is similar to English except for comas which sit on the line instead of under the line.
5. Arabic uses gender for all known nouns, no neutral ones.
6. Space is left between words in a sentence.
7. Some letters change shape depending on whether they are at the beginning, in the middle or at the end of the word.
8. There are 29 letters in Arabic with 3 letter sounds which do not even exist in the English language.
9. Arabic does not distinguish between vowels and consonants; the use of diacritics (a small sign on the top or under the letter) indicates the pronunciation.

According to [8], The Arabic-English language pair is known to behave more monotone than other language pairs, e.g. (Urdu-English or Chinese-English). In Arabic, all nouns are categorized into either feminine or masculine, hence, there is no neutral, and the gender can be either grammatical or natural. The gender of inanimate objects is grammatical, Animate objects have a natural gender, and this gender can be either non-productive or productive. The non-productive gender is the case of nouns where the feminine and the masculine have different lexical entries, i.e., the feminine is not derived from the masculine. By contrast, in the productive gender, the feminine is derived from the masculine, usually by adding a special suffix tamarbuta (ة) to the end of the masculine form (9).

To successfully conduct the process of translation, human translators need to have three types of

knowledge. The first knowledge of the source language (lexicon, morphology, syntax and semantics) in order to understand the meaning of the source text. Second type is the knowledge of the target language (lexicon, morphology, syntax and semantics) in order to produce a comprehensible, acceptable and well- formed text. The third type is the knowledge of the subject matter. This enables the translator to understand the specific and contextual between source and target language so as to be able to transfer lexical items and syntactic structures of the source language to the best matches in the target language [10].

2. RELATED WORK

During the last three decades, several approaches have been proposed for translating Arabic to and from other spoken languages as Arabic morphology poses both a challenge and an opportunity to MT researchers, some of these approaches using rules and grammars, other approaches relied on statistical methods. [11-12] developed an Arabic to English Machine Translation for both noun and verb phrases using transfer-based approaches, for the noun phrases MT they have managed to perform the syntactic reordering for this language pair, they achieved reasonable improvements in translation quality over related approach, Their method was tested on 88 thesis titles and journals from the computer science domain. The accuracy of their result was 94.6%. While in the verb phrase MT system their study was to introduce Verbal Sentence rule based Machine Translation, Their system was trained on 45 verbal sentences from different Arabic scientific text and tested on 30 new verbal sentences from different domains. They tested their system against two other machine translation systems namely Syzran and Google. The accuracy of the result was 93%. In [13] developed an Interlingual rule- based approach to translate from Arabic to English called UniArab, which is based on the Role and Reference Grammar Linguistic Model (RRG), they used the representation and the logical structure of an Arabic sentence. Their aim was to explore how the characteristics of the Arabic language will affect the development of a Machine Translation (MT) tool from Arabic to English

3. CHALLENGES OF ARABIC TO ENGLISH MT

Arabic is a highly agglutinative language with a rich set of suffixes. Its inflectional and derivational productions introduce a big growth in the number of possible word forms [14]. In Arabic, articles, prepositions, pronouns, etc. can be affixed to adjectives, nouns, verbs and particles to which they are related. The richness in morphology introduces many challenges to the translation problem to and from Arabic. In [14] mentioned that the divergence of Arabic and English language pair puts a rocky barrier in building a prosperous machine translation system. Morphological and syntactic pre processing is important in order to converge this language pair. Arabic words can often be ambiguous due to the tri-literal root system. This system allows the language to evolve and cover a wide range of meanings. In some derivations, one or more of the root letters is dropped, resulting in possible ambiguity. Arabic has a large set of morphological features [6]. These features are in the form of prefixes, suffixes and also infixes that can entirely change the meaning of the word. Moreover, Arabic has a relatively free word order, this poses another significant challenge to MT due to the vast possibilities to express the same sentence in Arabic.

4. SYSTEM DESIGN AND ARCHITECTURE

In his interesting paper, [1], stated that the translation process with transfer approach is decomposed into three steps: analysis, transfer, and generation. In the analysis step, the input sentence is analyzed syntactically (and in some cases semantically) to produce an abstract representation of the source sentence. In the transfer step, this representation is transferred into a corresponding representation in the target. language; In the generation step, the target-language output is produced.

The (morphological and syntactic) generator is responsible for polishing and producing the surface structure of the target sentence. (English), However. the system involves the following steps.

5. MORPHOLOGICAL ANALYSIS

Morphological Analysis: in this phase the analyser provides morpho-syntactic information and understanding the relationship among the different forms which a one word can take, the morphological analyser analyzes each word of the MSA sentence morphologically and applies certain rules before implementing the derivation rules [17]. Morphological Analyser select proper derivation/inflection rules based on the subject/noun features as well as the verb/adjective category of the input word i.e., (gender, number, and person). All of these features should be taken into consideration so as to get the correct derivation rules [18]. According to [19], the analysis of words in a machine translation system is needed to determine their syntactic and semantic properties. However, the morphological generator produces the inflected English words in their correct forms

5.1 Syntactic Analysis

Syntactic analysis, or parsing, is a major component in a rule-based MT system [20]. It is the process by which a sentence is analyzed into constituent parts, to determine grammatical structure. The syntactic analysis process utilises the Arabic dictionary and grammar rules to check the MSA input text in terms of spelling and grammar, then this information is used to produce the analysis of the text structure as an output (Parsing process). The parser divides the sentence into smaller sets depending on their syntactic functions in the sentence [1]. There are four types of phrases i.e. Verb Phrase (VP), Noun Phrase (NP), Adjective/Adverbial Phrase (AP), and Prepositional Phrase (PP). The syntactic analysis tries to handle a large difference of sentence constructions, however, once the tokeniser finishes executing, the parser accepts Arabic words list that builds a sentence and output a list of POS . We have used Stanford parser for this purpose. This particular process starts by assigning all possible POS i.e., Arabic POS list for each word Arabic words list in MSA entry sentence. After that it uses the rules to choose the POS which is suitable for combining all of the sentence words correctly. The next process is converting the MSA input sentence into a certain data structure representation. After obtaining the Arabic POS list, some semantic features have been applied for every word in Arabic words list, in which it deals with the agreement features between categories such as Subject and Object. It reduces the ambiguity of choosing the meaning of words. Moreover, the syntactic and generation processes analyze the phrasal structure and categories the Arabic sentence to generate the correct English structure sentence.

6. TRANSFORMATION MODULE

Transformation module is used to translate Arabic sentence structures and words; Transfer is the interface or link between the analysis and generation. However, the module consists of two main processes, they are:

6.1 Lexical Transfer:

This step is mainly designed for dictionary translation. according to [21], the replacement of a source lexical item by a target lexical item. In our system the lexicon is responsible for inferring morphological and classifying verbs, nouns, adverb and adjectives when needed. The task of this step is using the Arabic-English Bi-lingual dictionary to look up the English meaning for each word in the MSA phrase. This process is done word by word maintaining the same order as the MSA source phrase. The output of this step is a list of MSA words and their equivalent English meanings.

6.2 Structural Transfer:

This stage deals with the structure and patterns of the target sentences. The task of this step is to queue the words of target sentence up based on the English grammar rules. The transformation is done through two phases: Building a Bilingual dictionary and the transformation between Arabic and English languages; A Bilingual dictionary is an Arabic- to-English dictionary that contains the words in Arabic language and their corresponding equivalent meaning in English, however, the part of speech for the (SL) words is also added to the dictionary beside some other features such as humanity, alive, gender, tense, and numbers. The transformation starts after receiving the Arabic words list and Arabic POS list to generate the English words list. The system looks up in the bilingual dictionary for the translation of Arabic words and obtains the corresponding equivalent English words' meaning according to the transformer flow chart .

7. GENERATION MODULE

Generation is concerned with rendering the output of the target language (English) in a grammatically acceptable form in terms of its grammar structure and meaning translation. There are two steps to be accomplished in the generation module which are: morphological generation and syntactic generation. The morphological generator utilises English grammar rules to construct the correct forms of the inflected English words [22]. However, the task of the syntactic generation is to generate the English sentence in its final structure version. The syntactic generation process accepts the English words list to generate a sentence in a target language (English). It is the second final phase that reordering translated words according to various English rules. The target language is generated from source language sentences according to some of the following rules

1. Arabic verb phrase sentences:

    1.1. The verb in English sentence precedes the subject.

    1.2. The subject in English sentence precedes the object.

2. Noun phrase in both Arabic and English sentence have the same order. let us take an example on how the system handles the SL-TL word ordering based on the rules mentioned earlier, for the (SL) حل الطلاب المسألة الصعبةwhere XAL denotes ال , the corresponding English sentence matches the rule VBD/3;DT/1;XAL/1;NNS/2;DT/4;XAL/4;NN/6; XAL/4;JJ/5; then the reordering database matches the rule DT/1;NNS/2;VBD/3;DT/4;JJ/5;NN/6 based on the sequence the/DT students/NNS solved/VBD the/DT difficult/JJ problem/NN.

8. IMPLEMENTATION AND DESIGN

This section manifests the proposed prototype and the entire translation process. Full example with processes is also shown in figure 2, the designed prototype utilized the module developed by [23].

1. Analysis Module (Arabic text)

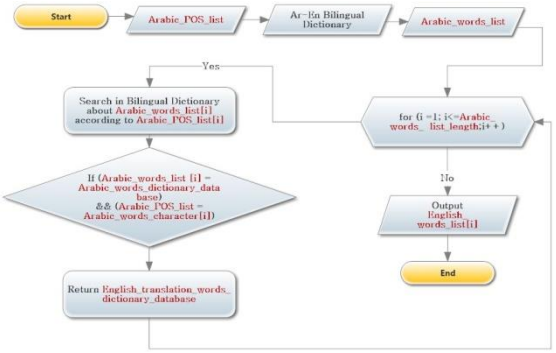


Fig 1 Transformation Flowchart

1.1 Input an Arabic sentence (SL)

1.2. Tokenizer

i. Divide the Arabic SL into tokens. ii. The result obtained is an n-sized array (n= the number of words).

1.3. Arabic (SL) Parsing (the parsing flow is shown in figure2)

i. Accepts a list of words Arabic words list[i].

ii. Get Arabic POS list[i].(Parsingisdoneby using Stanford parser).

iii. Apply semantic analysis for every word in Arabic words list[i].

iv. Produce an English sentence structure (حل/VBD الطلاب /DTNN المسألة/DTNN الصعبة/DTJJ).

v. The output is an array containing the parts of speech like noun, verb, auxiliaries, adjective, preposition etc.

2. Transfer Module (Arabic-English transformation)

2.1. Bilingual Dictionary (Arabic-English transformation): This is an Arabic-to-English dictionary that contains the words in Arabic and their corresponding translation in English. Collection of words captures variously from dictionaries, books, newspapers and media.

i. Arabic POS words is added to the dictionary beside some other features such as humanity, gender, tense, and numbers.

ii. Translate Arabic words to their equivalent English meaning as specified in the bilingual dictionary and the Arabic POS list[i].

iii. The module accepts Arabic words list[i] and Arabic POS list[i].

iv. The output is English words list[i].

3. Generation Module (English text)

3.1. Synthesis rules of TL (English)

i. The system accepts English words list[i].

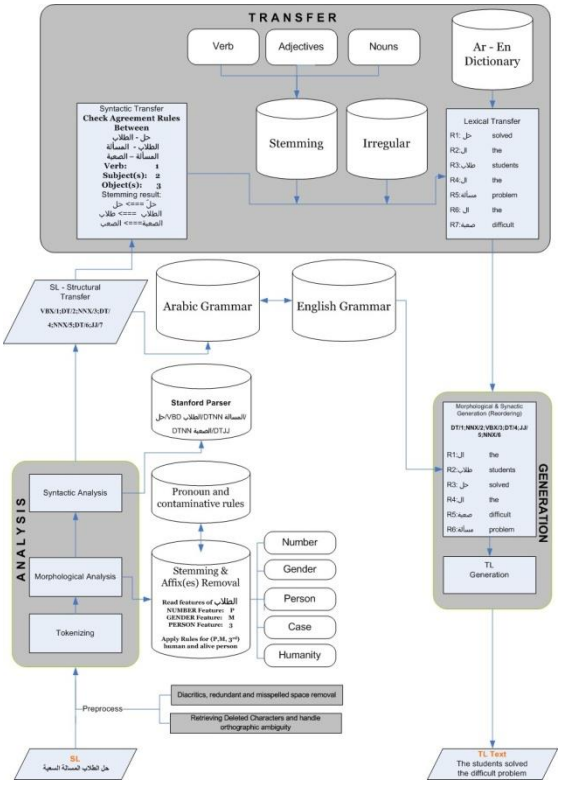
ii. Reorder English words list[i] based on the English structure list[i].

iii. Generate English sentence.

3.2. English Morphology

i. Match English Morphological rules with reordering English words list [i] to obtain a satisfactory translated English TL as shown in figure2.

The system architecture and design is illustrated with



an example in figures 2

Fig 2 System Architecture with example

9 EXPERIMENT AND RESULTS

In order to judge the translation accuracy received by AE- TBMT; we have developed an evaluation methodology. This methodology is based on a comparison between the system outputs with the original translation of the input text. The following steps describe the conducted methodology:

1. Run the system on the selected test case.

2. Compare the original translation with the system output.

3. Classify the problems that arise from the mismatches between the two translations.

4. Assign a suitable score for each problem. A range of score between 0 and 10 determines the accuracy of the translation. While 0 indicates absolutely incorrect translation and 10 indicates absolutely correct (matched) translation.

5. When a situation belongs to multiple problems compute its score average.

6. Determine the correctness of the test case by computing the percentage of the total scores.

In order to improve the translation output, the evaluation methodology is applied on successive stages that include a cycle of translation, error identification, correction, and re-translation until no more changes can be made. In the following subsections we describe the conducted experiment that evaluate the system and incrementally improve its output.

9.1 Experiment

The purpose of this experiment is to investigate whether the following machine translation systems, namely, ALKAFI, GOOGLE, TARJIM and our system, are sufficiently robust for coherent translating between Arabic and English. The evaluation methodology is applied on 130 independent test examples taken from different Arabic scientific text and different domain; we call this test group as (test suit). Basically, the methodology is based on applying comparison between the outputs of the MT systems and the original translation for the test examples. The experiment gives the following results as shown in table 1 and figure 3 below.

The percentage of the total score for each system has been found by dividing the total score by 1300; as we have 130 test examples and each is evaluated out of 10.

We have classified the problem caused ill-translation and assigned suitable scores for them based on their weight; we have classified the problems according to the following categories as follow:

1. Article-Noun: This problem appeared because the noun phrase that are preceded by a(n) is translated as if it were preceded by ”the”. In other words, the translation nouns and adjectives of this noun phrase are defined. We give an output that belongs to this problem 9.

2. Adjective-Noun: We give an output that belongs to this problem 8.

3. Verb-Subject: We give an output that belongs to this problem 8.

4. Demonstrative-Noun: We give an output that belongs to this problem 8.

5. Relative Pronoun-Antecedent: We give an output that belongs to this problem 7.

6. Predicate-Subject: We give an output that belongs to this problem.

7. Order of the adjective: This problem appeared because the translation of the adjective relative to its described noun is not translated in its right order. In other words, the adjective does not follow the described noun in order. We give an output that belongs to this problem7.

8. Successive words form an expression :This problem appeared because the successive words that form an expression are translated separately. We give an output that belongs to this problem 8.

9. Rough addition and deletion: This problem appeared because the original translation contains extra words that have no corresponding words in the input of the source language. We give an output that belongs to this problem 7.

Table 1 Result of test suit experiment.

	Al-Kafi	Google	Tarjim	AE-TBMT
Matches Sentences	97	94	87	112
Mismatches Sentences	33	36	43	18
Total Score of Matches Sentences	970	940	870	1120
Total Score of Mismatches Sentences	247.6	359.2	313.9	136.8
Matches Sentences	1217.6	1199.2	1183.9	1256.8
Percentage	93.6%	92.2%	91.1%	96.6%

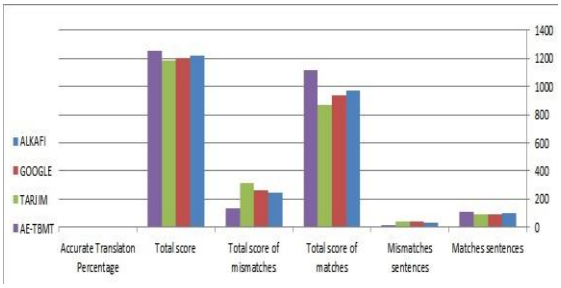


Fig 3 Test Suit results

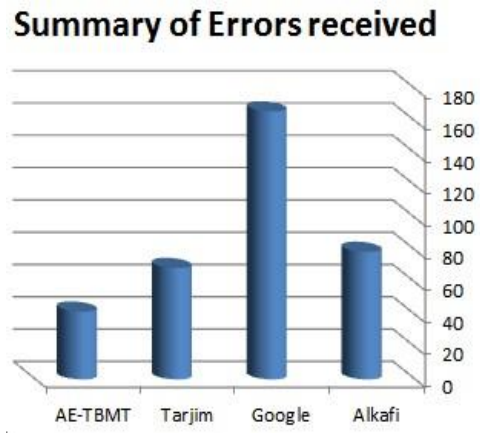


Fig 4 Summary errors results

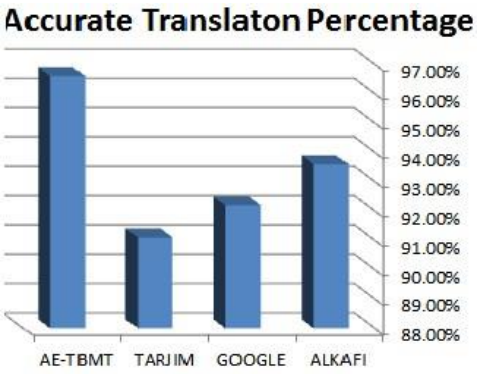


Fig 5 Translation percentage results

9.2 Type of Error Frequencies with English-Arabic MT

Table 2 represents all type of errors returned by each of the examined system, namely, Alkafi, Google, Tarjim and AE- TBMT, and their frequencies. If we examined the first row for the Article-Noun agreement we will find that this type of error frequented 4 times with Alkafi, 28 times with Google, 4 times with Tarjim Sakhar and only 2 times with our system. Therefore, as a total this type of error frequented 38 times with all of the systems. Figure 4 and figure 5 are representing the type of errors received after getting the translation with their frequencies for the Arabic MT system i.e., Al-Kafi, Google and Targim against our system (AE-TBMT).

The conducted experiment shown that our system has scored the highest percentage by 96.6 percent, this means that less than four percent of the entire test examples have not been handled correctly, and this result is considered fair if not good, as the other three systems score below that mark.

10 CONCLUSION AND FUTURE WORK

In this study we presented a transfer-based approach to handle the translation of MSA into English. This paper shows that many shortcomings in the output of MT are due to either faulty analysis of the SL text or faulty generation of the TL text. The improvement to the translation can be done only by formalizing our linguistic knowledge and enriching the computer with adequate rules to deal with the linguistic phenomenon [24]. The contribution of this paper can be summarized as follows: first: the development of patterns for Arabic and English sentences for translation purposes, second: the development of a MT system prototype which is superior as compared to other three existing systems. third: Highlighting major problems with current Arabic to English MT systems and suggest solutions to resolve these problems, and fourth: the construction of a tests suite; that has been used in testing different features that cause inaccurate translation in three Arabic Machine Translation systems, they are, ALKAFI, GOOGLE, TARJIM SAKHR versus AE-TBMT. These examples have been used in exploring and evaluating the faulty translation, In the experiment, we have classified the problems into nine categories and we compare the outputs of those four particular systems with the original translation of the SL.

The experiment proves that AE-TBMT has scored the highest percentage. Experimet sheds light on some major issues of available MT systems; i.e., Addition and deletion are serious problems that the developer of Arabic MT systems have to look at. Spelling is another issue that requires attention.

The issues discussed herein need to have developed rules and grammars in the future to give full coherent meaning. The lexical environment and collocations are very important guides that need to be adopted to help deciding the meaning and choosing the right equivalent translation between this particular language pair

Table 2 Type of Error Frequencies with Arabic MT system against AE-TBMT.

Error	Error Type	Frequency	Error Percentage	Al-Kafi	Google	Tarjim	AE-TBMT
1	Article-Noun Agreement	38	10.67%	4	28	4	2
2	Adjective-Noun Agreement	89	25%	19	33	19	18
3	Verb-Subject Agreement	50	14.04%	12	25	6	7
4	Demonstrative-Noun Agreement	5	1.40%	0	3	1	1
5	Pronoun-Antecedent Agreement	18	5.05%	6	6	3	3
6	Predicate-Subject Agreement	47	13.20%	16	10	16	5
7	Order of the adjective	25	7.02%	2	20	2	1
8	Successive words form an expression	3	0.84%	1	0	2	0
9	Rough addition and deletion	81	22.75%	19	41	16	5
	Total Frequencies of Errors	356		79	166	69	42

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