

RULE-BASED APPROACH TO TACKLE AGREEMENT AND WORD-ORDERING IN ENGLISH-ARABIC MACHINE TRANSLATION

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Abstract

Machine Translation has been defined as the process that utilizes computer software to translate text from one natural language to another. This definition involves accounting for the grammatical structure of each language and using rules and grammars to transfer the grammatical structure of the source language (SL) into the target language (TL). This paper presents an English to Arabic approach for translating well-structured English sentences into well-structured Arabic sentences, using a Grammar-based technique to handle the problems of ordering and agreement. The proposed methodology is flexible and scalable, the main advantages are: first, it is a rule-based approach, and second, it can be applied on some other languages with minor modifications. Apple Pie Parser (APP) has been developed using the C language, validation rules have been applied in both the database design and the programming code in order to ensure the integrity of data. A major design goal of this system is that it will be used as a stand-alone tool, and can be very well integrated with a general machine translation system for English sentences.

Keywords: MT, Agreement, Reorder, Rule-Based, lexicon, Parser, POS

1. INTRODUCTION

The current Machine Translation system facilitates the end user to understand the English textual sentences clearly by generating the precise corresponding Arabic language. Agreement is a basic property of language. In the most basic sense, agreement occurs when two elements in the appropriate configuration exhibit morphology consistent with their co-occurrence. Perhaps the most transparent case of this linguistic mechanism is number agreement between a subject and a verb: A singular noun in the subject position regularly co-occurs with a singular verb (e.g., “the dog runs”), and a plural subject noun regularly co-occurs with a plural verb (e.g., “the dogs run”). If the language has number marking on other elements, such as determiners or adjectives, these should also exhibit morphology that is consistent with their relationship to the subject head noun, and this co-occurrence relationship holds for gender and person agreement as well.

The modern Arabic dialects are well-known as having agreement asymmetries that are sensitive to word order effects. These asymmetries have been attributed to a variety of causes, first, by the analysis problems at the source language, second, the generation problems at the target languages. However, Arabic is not alone in showing word-order asymmetries for agreement, Similar asymmetries have been documented in Russian, Hindi, Slovene, French and Italian (Hutchins and Somers 1992). Languages are varied in the agreement requirements. Some of them like Arabic require number, gender, person, and case agreements while others need some of these agreements. Our purpose of this paper is to design a rule-based framework based on rules architecture to handle the problem of word agreement and ordering in the translation of sentences from English to Arabic.

2. AGREEMENT AND WORD REORDERING PROBLEMS IN MT

In this section we will explore different areas that are expected to cause agreement and reordering problems during translation from English into Arabic. To show how a certain grammatical phenomenon causes an agreement

problem, we will make use of ‘independent examples’. These examples are made-up sentences or phrases that contain an anticipated problem. The test examples will be put to the Arabic MT system [3].

2.1 Adjective-Noun Agreement

This type of agreement is not found in English. Arabic however, requires that the adjectives agree in number, gender, case and definiteness with nouns. In agreement, definiteness has a role to play: it is one of the features of agreement between adjectives and the nouns they modify. In Arabic, a noun may or may not have an article, but if the noun has one so must an attributive adjective (Abu Shquier and Sembok, 2007a). This is termed agreement in definiteness (Mohammad, 1990), and can be shown by the following examples:

1. house small (بيت صغير) a small house
2. the house the small (البيت الصغير) the small house

English adjectives are not marked for number or gender and so the predicative adjective does not agree with its subject. However, a predicate nominal must agree in number with the subject of its clause (Abu Shquier and Sembok, 2007b). Whereas Arabic adjectives require a number, gender and person agreements between the head word and the adjective. Here we will use the abbreviations sg, dl and pl to represent the singularity, dual and plural features respectively, and the gender features will be denoted as *m* for masculine and *f* for feminine.

Following are examples on adjective-Noun Agreement with THREE Arabic MT Systems:

- A diligent rich handsome man
 - (GOOGLE) جدية الاغنياء رجل وسيم [serious the rich(pl,m) man(sg,m) handsome(sg,m)]
 - (TARJIM) رجل وسيم غنيّ مجتهد
 - (SYSTRAN) يبحث غنيّة يهياً رجل [seeking rich good-looking man]
- A diligent rich handsome woman
 - (GOOGLE) جدية الاغنياء وسيم امرأة [serious the rich(pl,m) handsome(sg,m) woman(sg,f)]
 - (TARJIM) امرأة وسيم غنيّة مجتهدة
 - (SYSTRAN) يبحث غنيّة يهياً امرأة [seeking rich good-looking woman]
- Diligent rich handsome men.
 - (GOOGLE) المتقن الرجال الاغنياء وسيم [the serious the men (pl,m) the rich(pl,m) handsome(sg,m)]
 - (TARJIM) الرجال الوسيمون الأغنياء المجتهدون
 - (SYSTRAN) يبحث غنيّة يهياً رجال [seeking rich good-looking men]
- Diligent rich handsome women
 - (GOOGLE) المتقن الاغنياء وسيم المراه [the serious (sg,m) the rich(pl,m) handsome(sg,m) woman(sg,f)]
 - (TARJIM) النساء الوسيمات الغنيّات المجتهدات
 - (SYSTRAN) يبحث غنيّة يهياً نساء [seeking rich good-looking women]
- I saw the diligent rich handsome men.
 - (GOOGLE) رأيت الدؤوب الرجال الاغنياء وسيم [I saw the hard men(pl,m) rich(pl,m) handsome (sg,m)]
 - (TARJIM) رأيت الرجال الوسيمين الأغنياء المجتهدين [I saw the men (pl,m) the handsome (pl,m) the rich (pl,m) the diligent (pl,m)]
 - (SYSTRAN) أنا رأيت ال يبحث غنيّة يهياً رجال [I saw the to seek good-looking rich men]

Examples Analysis:

None of the examples above have been translated accurately with Google or Systran as they did not make the adjectives agree in number and gender with their nouns, in example a with Google, the adjective rich that describe the noun man had been marked as a plural masculine adjective, where it should be singular as it describes the noun man which is singular, same case with example b, neither the adjective rich nor handsome had agreed in number and gender with the noun woman, in examples c, d and e, we can also notice the adjective-noun disagreement clearly, as for systran, it just translate awkward and ill-ordered translation in all of the examples above.

Only Tarjim system successfully makes the adjectives agree in number and gender with their noun. Example e shows correct agreement in gender, definiteness, and case, as the three adjectives following the noun show. The system is also expected to successfully make agreement between a relative pronoun and the preceding noun. Neither agreement nor ordering had been handled by the other systems.

Features			English statement			Arabic translation		
Number	Gender	Person	Subject	Aux.	E. Verb	Verb (E. spelling)	A. verb	A. subject
Singular	M	1	I	am	Beautiful	Jameel	جميل	انا
		2	You	are				انت
		3	He	is				هو
	F	1	I	am		Jameel	جميل	انا
		2	You	are		Jameelah	جميلة	انت
		3	She	is				هي
Plural	M	1	We	are	Jameeloonn	جميلون	نحن	
		2	You				انتم	
		3	They				هم	
	F	1	We			Jameelat	جميلات	نحن
		2	You					انن
		3	They					هن
Dual	M	3	Ahmad and Salim		Jameelan	جميلان	احمد وسلام	
	F	3	Rabab and Salwa		Jameelatan	جميلتان	رباب و سلوى	

Table 1. The Adjective “beautiful” with Number, Gender and Person

The table above (adopted from Abu Shquier, M. and Attia, 2002) shows an example of the adjective (beautiful جميل) which is always the same English for case, number gender and person while it has many different forms in Arabic, depending on the number, gender and person of the head it describes.

Agreement can be handled, here, by adding suffixes to the different categories of adjectives according to the features of the described noun. like verbs, there are some irregular cases that don't follow straight the rules of adding suffixes to the adjective form that exist in the lexicon. The correct derivation form of the Arabic Adjectives depends on the features of the described noun, therefore, these cases will be stored in the irregular data base table that can be examined before applying the rules of adding suffixes. An example of this exception is the adjective clever meaning (thakei ذكي) where all its derivations can be generated by the common rule except when the described entity is a masculine plural. Here the plural form is irregular, it becomes (athkeia الذكاء) where according to the common rule it should be (thakeioon ذكيون).

If the statement has more than one adjective that describes the same noun, then the same features of that noun will be used in the derivation of the all adjectives:

The girl is clever and beautiful

The	“al”	ال
Girl	“bint”	بنت

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Clever	“thakei”	ذكي
And	“wa”	و
Beautiful	“jameel”	جميل

Arabic translation is:

“Al Bint Thakeiah wa Jameelah” البنت ذكية و جميلة

Non-human nouns: If the noun that the adjective describes is plural and doesn't have the humanity feature then the singular female form of the adjective is used instead of the plural form.

Examples:

- The men are beautiful “jameelon” الرجال جميلون
- The lions are beautiful “jamelah” الاسود جميلة

In the second sentence we have used the adjective “jamelah جميلة” which is singular female form with a plural noun “the lions”, while the plural male “jameelon جميلون” with “the men” in the first sentence. The difference between the two sentences is the humanity feature. The men are human while the lions are not. Again this is not everything about the adjectives, just a brief account to clarify the need for the agreement rules in MT.

2.2 Verb-Subject Agreement

If a sentence contains a singleton subject noun phrase, how the verb is marked for agreement depends on the word order of the subject relative to the verb. In verb subject order the verb agrees with the subject only in gender and is marked in the singular, whether the subject is singular (1) or plural (2). Plural marking on the verb is only acceptable if the noun phrase is interpreted with contrastive focus as a SUBJ (3):

1. The boy wrote the paper كُتِبَ الولد الواجب
2. The boys wrote the paper كُتِبَ الاولاد الواجب
3. The BOYS wrote the homework (and not the girls) كُتِبَ الاولاد الواجب ولا البنات

In subject verb word order the verb agrees with the subject noun phrase in gender and number. If the subject is singular, the verb is marked as singular (4); if the subject is plural, the verb must be marked as plural (5); singular marking is unacceptable (6):

4. The boy wrote the paper الولد كتب الواجب
5. The boys wrote the paper الاولاد كتبوا الواجب
6. The boys wrote the paper الاولاد كتب الواجب

In sentences with an initial auxiliary verb both the verb subject and the subject verb rules apply. In Aux-subject-verb word order, the auxiliary agrees only in gender while the main verb agrees in both gender and number:

7. The girl was writing the paper كانت البنت تكتب الواجب
8. The girls were writing the assignment كانت البنات يكتبن الواجب

If the subject precedes the auxiliary, then both verbs agree with it in both gender and number:

9. The girl was writing the paper البنت كانت تكتب الواجب
10. The girls were writing the assignment البنات كن يكتبن الواجب
11. The girls were writing the assignment البنات كانت يكتبن الواجب

The agreement patterns in verb- subject vs. subject-verb word order are summarized in the following diagrams:

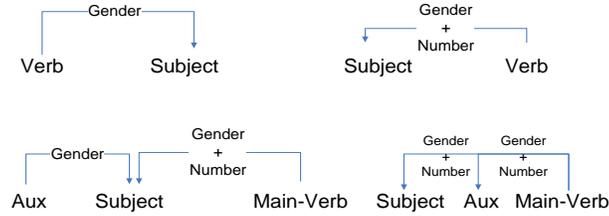


Figure 1. Agreement patterns in verb-subject vs. subject-verb word order

Arabic shows yet a more complex system in verb agreement than any other language, as the verb agrees with the subject in person, number, and gender. Both Arabic and English reflexives and possessives agree with their antecedents in gender, number (singular dual, or plural) and person. (e.g., He eats his food. or She eats her food.)

Table 2, shows that the verb play in English has only two forms in the simple present tense. They are plays with he, she, and it (the singular third person for both males and females), and play with all other subjects regardless of their number and gender. The same table shows that Arabic has many derivations (different words) for the same verb play because of the number gender and person of the subject.

Features			English statement		Arabic translation		
Number	Gender	Person	Subject	E. Verb	Verb (E. spelling)	A. verb	A. subject
Singular	M	1	I	Play	Alab	العب	انا
		2	You		Talab	تلعب	انت
		3	He	Plays	Yalab	يلعب	هو
	F	1	I	Plays	Alab	العب	انا
		2	You		Talabei	تلعبين	انت
		3	She	Plays	Talab	تلعب	هي
Plural	M	1	We	Play	Nalab	تلعب	نحن
		2	You		Talaboon	تلعبون	انتم
		3	They		Yalaboon	يلعبون	هم
	F	1	We		Nalab	تلعب	نحن
		2	You		Talabn	تلعبن	اننن
		3	They		Yalabn	يلعبن	هن
Dual	M	3	Ahmad and Salim	Play	Yalaban	يلعبان	احمد وسلام
	F	3	Rabab and Salwa		Talaban	تلعبان	رياب و سلوى

Table 2: The verb “play” with number, gender, and person features of the subject [6].

The examples in table II are all of the structure type subject and verb without an object, Let us now add an object to the statement and see what will happen.

- The boy plays football everyday كل يوم يلعب الولد كرة القدم
- The boy plays the children everyday يلعب الولد الاطفال كل يوم

It is clear from the two examples that the verb plays becomes two different words when it is translated to Arabic. The two statements are of the same structure and the only difference is in the features of the verb and objects. In the first statement the object (football) is inanimate while in the second one (the children) it is animate, furthermore, an infix is added to the verb when the object has the animate feature. During the implementation stage if we discover any need for extra features that affect the derivation of the correct form of the verbs and adjectives in the Arabic sentence, we will add them to the lexicon and manipulate in the programs/modules.

Is this everything? The answer is no. Let us examine the following example:

- The boy sells bread يبيع الولد الخبز
- The boy sells cats يبيع الولد القطط

It is clear from the above statements that the verb sells is translated by the same word in both of them through the object (bread), in the first one is inanimate and (cats) in the second is animate. Therefore, the addition of an infix to the verb depends also on the features of the verb itself. All these concerns will be taken into consideration during the implementation stage.

The question now: is it possible to generate all different derivations of the verb for all verbs by following a fixed set of rules? The answer to this question is definitely no. Regardless of the number of categories that can be identified to classify the verbs, there will be some irregular cases that don't follow the derivational rules and therefore, need different manipulation. In our design these irregular cases will be stored a separate table that can be examined before applying the rules of adding suffixes to derive the suitable Arabic translation form of the verb.

What about Arabic verbs in future tense?, the generation of the verb in future tense needs two steps: first generate the present form of the verb and then add the prefix “sa س” or add the particle “sawfa سوف ” immediately before the present verb form. Either form will give the meaning of futurity. This addition to the present verb is the equivalent translation of the modal “will” in English. Other forms of English future expression will need a different treatment:

The following examples explain this:

- The boy plays football يلعب الولد كرة القدم
 - The boy will play football سيلعب الولد كرة القدم
 - The boys play football يلعب الاولاد كرة القدم
 - The boys will play football سوف يلعب الاولاد كرة القدم
- سييلعب الاولاد كرة القدم Or سوف يلعب الاولاد كرة القدم

In the examples above the verb (Play) was translated according to the subject features; when the subject is either singular or plural male no suffixes will be added to the verb. Fortunately, if the statement has more than one verb for the same subject then the same features of the subject and the same grammar rules will be used in the derivations of the Arabic translation for both verbs. Singular instead of plural: the third Singular form of the verb is sometimes used with a plural subject instead of the plural form. For example, if a present simple, past simple, and present perfect sentence has a plural subject, verb, and a complement then Arabic language uses the singular form of the verb instead of the plural form, so the masculine third person singular verb is used with a masculine plural subject, whereas the third feminine third person singular verb with a feminine plural subject. This is described in the following examples:

- The boys play everyday يلعب الاولاد كل يوم
- The girls play everyday تلعب البنات كل يوم
- The boys play football يلعب الاولاد كرة القدم
- The boys are playing football الاولاد يلعبون كرة لقدم
- The girls are playing football البنات يلعبن كرة القدم

Observe that we used in the third sentence the singular male form of the verb “yalab يلعب “ instead of “yalaboon يلعبون “ which is assumed to be used with the plural male noun subject “the boys” as the case with the fourth sentence. And in the second sentence we used “ talab تلعب “ instead of “yalabn يلعبن” with the plural female subject “the girls” as the case with the fifth sentence. However, the position of the subject in relation to the verb is of utmost important.

In case of the Non human subject, If the subject of the sentence is masculine plural and doesn't have the humanity feature like animals then the singular female form of the verb is used instead of the plural form, as described in the following:

The men eat	“ya'koloon”	الرجال يأكلون
The lions eat	“ta'kol”	الاسود تأكل

In the second sentence we used the verb “تأكل ta'kol” which is singular female form with a plural male subject “the lions”, while it is “يأكلون ya'koloon” with “the men” in the first sentence. The difference between the two sentences is the humanity feature: men are human being while lions are not.

2.3 Pronouns

Only the pronouns he and she do not cause an agreement problem during translation into Arabic because they are clearly marked for number and gender. The other English pronouns *you*, *they*, *it*, *I* and *we* cause an agreement problem. This is due to the fact that the Arabic pronoun system differs from the English one in that the Arabic system includes a larger number of pronouns to allow for the distribution of features such as: singular, dual, plural, feminine, and masculine. The English pronouns you and they are not marked for gender and its number is ambiguous from the Arabic point of view which distinguishes between dual and plural:

Test examples: Pronoun *They* with Tarjim:

- They are two good boys. هم ولدان جيّدان
- They are two good girls. هم بنتان جيّتان
- They are good boys. هم أولاد جيّون
- They are good girls. هم بنات جيّات
- They are good cats. هم قطط جيّة

Analysis:

The system uses the default masculine plural form of the pronoun in all cases. This is correct only in example c. In all other examples, pronoun choice is wrong. The English pronoun it is not marked for gender. It is not clear whether it refers to a masculine or feminine object. Arabic, however, needs this distinction

Test Examples: Pronoun *It* with Tarjim:

- It is a good bull. إنّه ذكر كامل.
- It is a good cow. إنّها بقرة كاملة.

Analysis:

The system uses the default masculine singular form of the pronoun in example a. and this is correct. In example b the pronoun choice agree in gender with the noun it refers to. The pronoun we is not marked for gender and its number, from the perspective of Arabic, is ambiguous (dual or plural). Arabic does not have translational varieties of the pronoun, yet some agreement specifications depend on these features:

Test examples: Pronoun *We* with Tarjim:

- The two boys said, “We are good.” نحن جيّون
- The two girls said, “We are good” نحن جيّون
- The boys said, “We are good”. قال الأولاد، نحن جيّون
- The girls said, “We are good”. قالت البنات، نحن جيّون

Analysis:

The translation in example c is correct. Despite the fact that the pronoun we has only one translation, its hidden number and gender specifications affect the choice of the form (gender and number) of the predicative adjectives. In examples a, b and d the translation should be نحن جيّدان, نحن جيّدلن, and نحن جيّدات respectively. The pronoun *I* is not marked for gender. Arabic does not have translational varieties of the pronoun, yet some agreement specifications depend on these features:

Test examples: Pronoun *I* with Tarjim:

The boy said, "I am good." أنا جيّد
 The girl said, "I am good." أنا جيّد .

Analysis:

Only the translation in example a is correct. Despite the fact that the pronoun I has only one translation, its hidden number and gender specifications affect the choice of the form (gender) of the predicative adjectives. It is not clear why the sentences here do not follow the preferred verb-subject order (VSO).

3. PROPOSED SOLUTION FOR HANDLING AGREEMENT AND WORD-ORDERING

Let us investigate the translation with Arabic MT system and see how it can handle the agreement and word-ordering, using the following example:

- You are two good boys.

The correct translation is أنتما ولدان جيّدان [anotma (dl,m) oldan (dl,m) jidan (dl,m)] , the pronoun you should be marked for gender 'male' and number 'dual'. Below is the same sentence, and how it had been translated with four MT systems:

MT system	Translation
(ALMUTARJIM AL ARABI)	أنت ولدان جيّدون [anta (sg,m) oldan (dl,m) jidon (pl,m)]
(GOOGLE)	انت اثنين من الفتيان حسن [anta (sg,m) athnin mn alftian (pl,m)Hsn (sg,m)]
(TARJIM)	أنت ولدان جيّدان [anta (sg,m) oldan (dl,m) jidan (dl,m)]
(SYSTRAN)	أنت اثنان فتي جيّدة [anta (sg,m) athnan fta (sg,m) jidah(sg,f)]
(RBMT)	أنتما ولدان جيّدان [anotma (dl,m) oldan (dl,m) jidan (dl,m)]

The pronoun you is not marked for gender and its number is ambiguous as it can refer to singular أنت [anta], dual أنتما [antoma], and plural أنتم [antom] entities. The translation of this pronoun as well as the agreement specifications of the target words depends on clear identification of these features.

The above example shows that all the systems, namely: Almutarjim Al Arabi, Google, Tarjim and Systran used the default masculine singular form of the pronoun. Where it is clearly wrong, The pronouns should be أنتما [antoma] as it is with RBMT, for instance, in example a with ALMUTARJIM AL ARABI the pronoun you is describing the two-boys, and the adjective good should agree with the two-boys as well. But actually the system has translated you as the default singular masculine form انت [anta], where it should be marked for gender 'male' and number 'dual' and translated as أنتما [antoma], same case with good as it should agree with the noun two-boys and marked as masculine dual, but it had been marked as masculine plural with ALMUTARJIM AL ARABI.

3.1 Proposed Solution with RBMT

In a rule-based machine translation system the original text is first analyzed morphologically and syntactically in order to obtain a syntactic representation. This representation can then be refined to a more abstract level putting emphasis on the parts relevant for translation and ignoring other types of information. The transfer process then converts this final representation (still in the original language) to a representation of the same level of abstraction in the target language. These two representations are referred to as "intermediate" representations. From the target language representation, the stages are then applied in reverse.

Figure 2, represents the whole process. Various methods of analysis and transformation will be used before obtaining the final result. The methods which are chosen and the emphasis depends largely on the design of the system, however, the system includes the following stages:

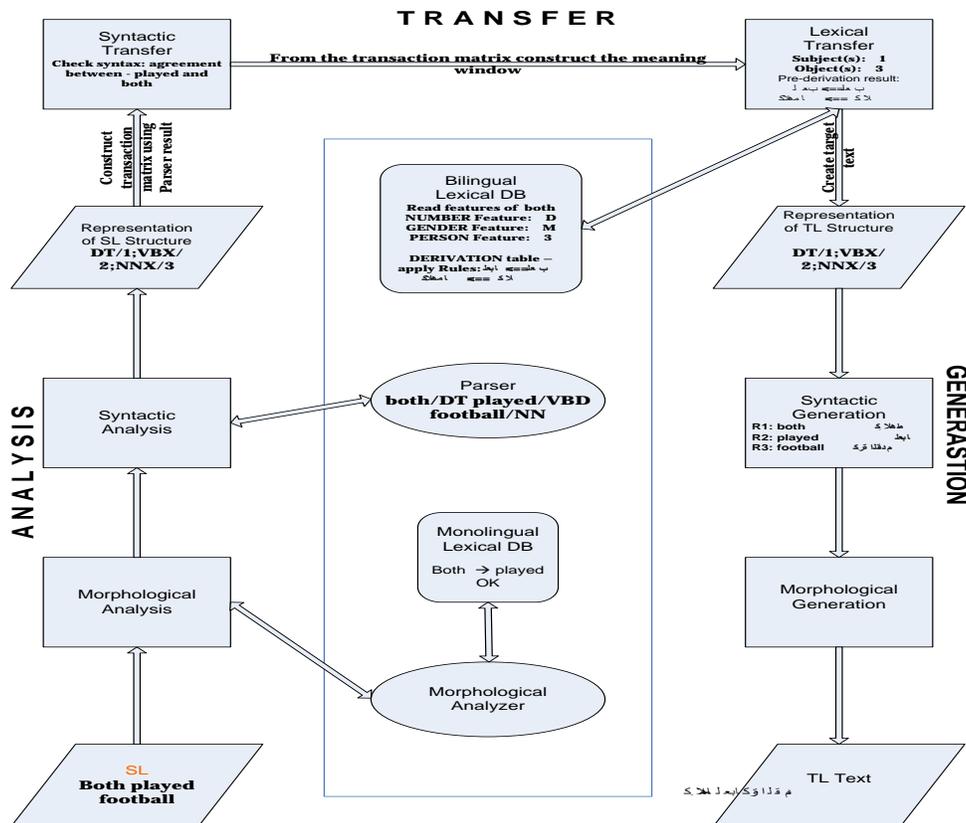


Figure.2. RBMT Process.

4. CONTRIBUTION

The principal practical achievement of this paper is the construction of an agreement and ordering tests suite; that has been used in testing different agreement and ordering features in four Arabic Machine Translation systems.

ALKAFI, GOOGLE, TARJIM SAKHR and SYSTRAN versus EA-RBMT. These examples have been used in exploring and evaluating the agreement and ordering problems throughout three experiments.

5. CONCLUSION

Many shortcomings in the output of MT have been shown in this paper, due to either faulty analysis of the source language text or faulty generation of the target language text. Enhancement to the output can be done only by formalizing our linguistic knowledge and enriching the computer with adequate rules to deal with the linguistic phenomenon. Fully automated, high quality machine translation (FAHQMT) has not yet been achieved. Yet there is a lot that we can do to improve the quality of MT output and increase its usefulness

In this paper we have presented the necessity to handle both the agreement and the words reordering in the machine translation from English to Arabic. We proposed a rule-based approach to solve those problems; the paper has dealt with two features that greatly affect the output of MT, that are agreement and ordering problem which comes from the fact that different languages have different text orientation where some of them are left-to-right and others are right-to-left. The order of the words in the sentence is also different from one language to another.

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