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Hybrid-Based Approach to Handle Irregular Verb-Subject Agreements in English-Arabic Machine Translation

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Abstract: Arabic is a highly inflectional language, with a rich morphology, relatively free word order, and two types of sentences: nominal and verbal. Arabic natural language processing in general is still underdeveloped and Arabic natural language generation is even less developed [32]. Word ordering plays an important role in the translation process between languages. This research is presenting work-in-progress to examine the implications of using verb subject object (VSO) and subject verb object (SVO) words order when dealing with the agreement requirements of irregular verbs in MT. several distinguishing cases of Arabic pertinent to MT will be explored in detail with reference to some potential difficulties that they might present. Irregular verbs can be defined as verbs that act differently from the basic patterns in all or some cases [31]; the definition of irregular verbs involves accounting doubled, hamzated and weak verbs. There are four categories of weak verbs depending on the position of the weak letter/Vowels in the root (first, middle, last letter, or more than one letter). The paper presents formalism to best suit word orders based on rules and examples of part of the morphological knowledge of the Arabic language based on irregular verbs and their derivatives. We will first perform a thorough study of irregular verbs of the Arabic Language and propose a model that is based on set theory and ontologies. We then show how this model can be used for some applications that include NLP applications. **Approach:** The main objective of this research is to reinforce a hybrid-based MT (EA-HBMT) to improve the quality of MT from English to Arabic. Arabic lexicon would be supported by a strong theoretical framework and implemented using robust tools that will facilitate its implementation. Rules will be used to recognise the derivative and inflexional nature of the Arabic language. Transfer-based MT is used to obtain an intermediate representation that captures the "meaning" of the original sentence in order to generate the correct translation. Example based-technique is used as well to handle the irregular cases. Semantic process is mainly conducted to detect the statements that require the use of SVO construction rather than VSO. **Results:** in this paper we built a module to detect irregular verbs, i.e, doubled, hamzated, Mithal, Hollow, defective, and enfolding. A set of 30 rules have been conducted based on the tense of the verb, place of the vowel root letter, first, second or third person representation, number and gender features, and diacritics preceding vowel letter, i.e., nominative, accusative or genitive case. Our proposed module has been effectively evaluated using real test data and achieved satisfactory results.
Keywords: *MT, agreement, irregular-verbs, hamzated, doubled, hollow, defective, word-ordering, SVO, VSO, affixes, suffixes, EA-HBMT.*

1. Introduction

Arabic verbs are constructed on a root that uses three consonants that is known as (Morphological balance) ($C_1aC_2aC_3a$)[1] [2] to identify the basic meaning of the verb. However, the multifarious vowels and affixes are attached to the root verbs to create the desired inflection of the meaning. Each root can generate a vast number of meanings, of which all are predictable in form and related to the basic meaning of the three root letters. Arabic roots can be classified into two classes; the Vowelized roots and Non-Vowelized Roots [13][6]. This classification was made in accordance with the availability of the Arabic vowels in the roots. (Wightwick, J and Gaafar M. 2008) stated that Waaw (و) and yaa' (ي) are often called weak letters, and the verbs they contain called weak verbs. However, a weak letter must be preceded by a corresponding short vowel and not followed by any vowel in order to become a vowel. Arabic is comprised of three short vowels that are similar to the "*i*" like in "bit", the "*a*" in fat and the "*oo*" in the word "foot". The short vowels are clarified by diacritics that are appearing above or below the consonant letters in the orthography [38]. The previous studies in the Arabic language research explained that the greater portion of the Arabic root verbs are of trilateral origin while the remaining are of quadriradical and biliteral origin [5].

Irregular verbs can be defined as verbs that act differently from the basic patterns in all or some cases.

[1] The reference that we have used as sources of data is related to the Arabic Morphological Balance: Al Rajihi (1993), Wright (1967), Al-Hamalawi (1991), Omer et. al. (1984), Yaqub(1988), Makram (1987), Al-Dahdah (1991), Al-duqur (1986), and Mustafa et. al. (1989).
[2] To clarify the structure of Morphological forms we have used the corresponding CV array of each form alongside. C_{ns} corresponds to radical letters, and represent the consonants of فعل

There are four categories of weak verbs depending on the position of the weak letter/Vowels in the root (first, middle, last letter, or more than one letter). Doubled verbs as well are also considered as irregular verbs, doubled verbs are those verbs that end with two identical consonants with no short vowel between them, whereas weak verbs are verbs that have original weak letters (*y* or *w*). in other words, verbs whose roots contain one or more weak letters.
According to (Wightwick, J and Gaafar M., 2008) Weak verbs are the largest category of irregular verbs. They can be subdivided into four types depending on which of the root letters is affected:

• Verbs with waaw or yaa' as the first root letter (Mithal verbs).
• Verbs with waaw or yaa' as the second root letter (Hollow verbs).
• Verbs with waaw or yaa' as the third root letter (Defective verbs).
- verbs that have two weak letters in their roots (Enfolding verbs)

Arabic language plays a crucial role with the root ($C_1aC_2aC_3a$) to add subtle variations to the meaning. There are eight significant derived forms (for the singular masculine 3rd person in the present tense) as shown in table 1 below:

Table 1 Eight significant derived forms

Form I	$yaC_1C_2aC_3$	يفعَل
Form II	$yuC_1aC_2C_2iC_3$	يفَعِّل
Form III	$yuC_1aC_2iC_3$	يُفاعِل
Form IV	$yuC_1C_2iC_3$	يُفعِل
Form V	$ytaC_1aC_2C_2aC_3$	يَتَفَعَّل
Form VI	$ytaC_1AC_2aC_3$	يَتَفاعَل
Form VII	$yanC_1aC_2iC_3$	يَنفَعِل
Form VIII	$yaC_1taC_2iC_3$	يَفتَعِل
Form X	$ystaC_1C_2iC_3$	يَستَفعِل

In this section we are going to explore the behavior of irregular verbs of the forms I through X.

Doubled verbs behave as regular verbs in form II. (Doubling the middle root letter (C_2C_2) means that the second and third root letters of a doubled verb are always written separately. in forms III and IV they follow the same rules as for the basic doubled verb. Form IV doubled verbs are much more common than form III. Let us investigate these forms through table 2 shown below for the present tense doubled-verb pass (يمرّ).

Table 2 derivation for the doubled-verb pass (يمرّ).

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
1st - Masc 1st - Fem	مررتُ	أمرّ					مررنا	نمرّ	
2nd – Masc 2nd - Fem	مررتَ مررتِ	تمرّ تمرّين	امرر مرّي	مررتما	تمرّان	مرّا	مررتم مررتنّ	تمرّون تمررن	مرّوا امررن
3rd – Masc 3rd – Fem	مرّ مرّت	يمرّ تمر		مرّا مرّتا	يمرّان تمرّان		مرّوا مررن	يمرّون يمررن	

From the table above we can conclude that the doubled-verbs are dependent on the vowel over the 3rd root letter, hence, the doubled root letters are written separately if the 3rd root letter (C_3) has a sukuun over it, and written together if it does not.

Verbs with hamzah (hamzated-verb) behave roughly just like regular verbs with some exceptions: when hamzah comes as a first root letter (C_1) then the past tense of forms III and IV starts with maddah (آ). e.g., the verb believes (يؤمن) has to be written in form IV as believed (آمَنَ), nevertheless, when hamzah comes in the middle (second) root letter (C_2) then it has to be written on the line in form III as it follows a long vowel. e.g., the verb asks (يسأل) with past tense asked (سأَل) has to be written in form III as questions (يسائِل). See table 3 below:

Table 3 derivation for the hamzated-verb read (يقرأ).

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
1st - Masc 1st - Fem	قرأتُ	أقرأ					قرأنا	نقرأ	
2nd – Masc 2nd - Fem	قرأتَ قرأتِ	تقرأ تقرأين	اقرأ اقرئي	قرأتما	تقرءان	اقرءا	قرأتم قرأتنّ	تقرأون تقرأن	اقرأوا اقرأن
3rd – Masc 3rd – Fem	قرأ قرأت	يقرأ تقرأ		قرءا قرأتا	يقرءان تقرءان		قرأوا قرأن	يقرأون يقرأن	

We have to notice here that verbs with hamzah attached to pronouns the same way regular verbs do, except for some cases:

1. Omitting first root letter (C_1) of (took, ate) in the imperative as shown in tables 4 and 5 respectively.

Table 4 derivation for the first root hamzated-verb take (يأخذ).

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
2nd -Masc 2nd- Fem	أخذتَ أخذتِ	تأخذ تأخذين	خذ خذي	أخذتما	تأخذان	خذا	أخذتم أخذتنّ	تأخذون تأخذنّ	خذوا خذن

In table 3 above we have seen that the verb took (أخذ) ($C_1aC_2aC_3a$) lost his 1st root letter (C_1) when it is conjugated with imperative.

Same amendments for the past tense of the verb eat/ate, see tables 5 and 6 below:

Table 5 derivation for the first root hamzated-verb eat (يأكل)

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	imp

2nd - Masc	أكلتَ	تأكلُ	كُلْ	أكلتما	تأكلان	كلا	أكلتم	تأكلون	كلوا
2nd - Fem	أكلتِ	تأكلين	كلي				أكلتنّ	تأكلنَ	كلن

Table 6 derivation structure for the first root hamzated-verb eat (يأكل) – omitting C_1 with imperative

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
2nd - Masc	أكلتَ	تأكلُ	(C_2uC_3)	أكلتما	تأكلان	(C_2uC_3aa)	أكلتم	تأكلون	(C_2uC_3uu)
2nd - Fem	أكلتِ	تأكلين	(C_2uC_3i)				أكلتنّ	تأكلنَ	(C_2uC_3na)

the verb ate (أكل) ($C_1aC_2aC_3a$) lost his 1st root letter (hamza)(C_1) when it is conjugated with imperative.

Let us investigate this rule through another example of the verb (to order) as shown in table 7

Table 7 derivation for the first root hamzated-verb order (يأمر)

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
2nd - Masc	أمرتَ	تأمُر	مُر	أمرتما	تأمران	مرا	أمرتم	تأمرون	مُروا
2nd - Fem	أمرتِ	تأمرين	مُري				أمرتنّ	تأمرنَ	مرن

one can conclude that the verb to order (يأمر) ($yaC_1C_2uC_3u$) lost his 1st root letter (hamza)(C_1) when it is conjugated with imperative as well.

2. Omitting second root letter (C_2) of (ordered, asked) in the imperative under a condition of being at the beginning of the speech. These two verbs irregularly lose their 1st hamza(t)'s in the imperative; but they can keep it if they were not the first words in the sequence of speech.

Table 8 derivation for the second root hamzated-verb ask (يسأل)

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
2nd - Masc	سألتَ	تسأل	سَل	سألتما	تسألان	سَلا	سألتم	تسألون	سَلوا
2nd - Fem	سألتِ	تسألين	سَلي				سألتنّ	تسألنَ	سَلن

From the examples above in tables 2 through 8 we can conclude that:

• If the hamza is at the beginning of the verb, it is written on an 'alif'. e.g., 1st masculine singular present tense (to read): أقرأ

• with 1st masculine singular present tense you would need to write two 'alifs, then these are combined as one with a madda sign over it (آ), pronounced as a long aa. e.g., se (to eat) : آكلُ

• Otherwise, the letter carrying the hamza tends to relate to the vowel before the hamza:

– Damma (ُ) before hamza (nominative case)= hamza written on waaw (ؤ)

– Kasra (ِ) before hamza (genitive case) = hamza written on 'yaa', without dots (ـئـ or ئ)

– FatHa (َ) before hamza (accusative case)= hamza written on 'alif (أ)

• If the hamza has no vowel before it (i.e., the letter before has a sukuun over it), then the rules above default to the vowel over the hamza itself: to ask (يسألُ) as shown in table 8.

Methal verbs are verbs whose 1st root letter is either 'و' or 'ي'. As for form IV, methal verbs have a long *uu* vowel at the beginning of the present tense. See table 9 below:

Table 9 derivation for the first root methal-verb describe (يصف)

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
1st - Masc	وصفتُ	أصفُ					وصفنا	نصفُ	
1st - Fem									
2nd – Masc	وصفتَ	تَصفُ	صِف	وصفتما	تَصفان	صِفا	وصفتم	تَصفون	صفوا
2nd - Fem	وصفتِ	تصفي	صفي				وصفتن	تصفن	صفن
3rd – Masc	وصف	يصفُ		وصفا	يصفان		وصفوا	يصفون	
3rd – Fem	وصفت	تصف		وصفتا	تصفان		وصفن	يصفن	

Actually, the table above shows regularity in the past tense but the case is different with present and imperatives as we will see in next section, Verbs will lose their first original letter (C_1) (the weak letter) if the short vowel following the second root-letter (C_2) is *i*, and sometimes if it is *a*.

Hollow verbs are those verbs with waaw or yaa' as the first or second root letter, hollow verbs behave as regular verbs in forms II and III. However, in form IV hollow verbs behave as they do in the basic pattern. They have a short vowel in the middle if the third root letter has a sukuun over it, but this is the short vowel connected to the derived pattern. See table 10 below:

Table 10 derivation for the second root hollow-verb say (يقول)

	Singular			Dual			Plural		
	Past	Pres	Imp	Past	Pres	Imp	Past	Pres	Imp
1st - Masc	قلتُ	أقولُ		قلنا	نقول		قلنا	نقول	
1st - Fem									
2nd – Masc	قلتَ	تقول	قل	قلتما	تقولا	قولا	قلتم	تقولون	قولوا
2nd - Fem	قلتِ	تقولي	قولي				قلتنَّ	تقلنَ	قلن
3rd – Masc	قال	يقول		قالا	يقولا		قالوا	يقولون	
3rd – Fem	قالت	تقول		قالتا	تقولا		قلنَ	يقلنَ	

We have seen here that the second vowel letter (C_2) has been omitted in the following cases

- 1st past singular, 1st past dual, and 1st past plural for both masculine and feminine.
- 2nd past singular, 2nd past dual, and 2nd past plural for both masculine and feminine
- 2nd masculine singular imperative, 2nd feminine plural present and 2nd feminine plural imperative.
- 3rd feminine plural past and 3rd feminine plural present.

Defective verbs are verbs whose last original letter is a weak letter the original weak letter can be either w or y. Verbs whose last original letter is 'alif أ are not weak verb. Just like the hollow verbs (as will be shown latter), the final w or y of these verbs can change based on the preceding short vowel. however,

defective verbs behave irregularly in all forms of II, III and IV.

In any Arabic word with more than three letters, the final weak 'alif will take this form ى (alif maqsorah/broken alif) regardless of its origin. When such an 'alif is transformed back to a weak letter, likely wise, when conjugating defective verbs, it will be always transformed to y regardless of its true origin. let us investigate this rule through the following example: the verb threw (رمى) is originally came from the form (رمَيَ) because when we use it with 3rd masculine singular present tense it would be to throw (يرمي), while it is with 3rd masculine plural present tense would be (يرموا).
On the other hand, the verb invited (دعا) is originally came from the verb (دعوَ) because when we use it with 3rd masculine singular present tense it would be to invite (يدعي) while with 3rd masculine plural present tense it would be (يدعو). Therefore, one can claim that Arabic does not have a true weak 'alif at all. All the weak 'alif's are transformed from y's or w's (and sometimes from other things). Thus, there is no real long A vowel in Arabic

Enfolding verbs are categorize into two groups, one that have a middle and final weak original letters and the other group is the one that have a first and final weak original letters. From the definition we can conclude that the first group enfolds the definitions of both hollow and defective verbs, yet it is always treated as a defective verb only, and the middle weak letter is treated as if it were a regular letter. While the second group enfolds the definitions of both Mithal and defective verbs. These verbs get the dealing of both Mithal and defective verbs together.

In the next sections we are going to discuss the morph-syntactic agreement features in the translation into Arabic based on words order combinations VSO and SVO, considering number, gender, case and person features.

2. Review of Literature

Arabic is the fourth most widely spoken language in the world. It is a highly inflectional language, with a rich morphology, relatively free word order, and two types of sentences[3][4].

Verbs in Arabic are categorised in different ways according to the needs of the grammarians or applications. Verbs can be classified based on the number of characters that form their root, or based on the nature of characters forming their root as this will influence their conjugation and the forms of their derivations [5].

Shaalan (2005) defined weak verbs as those verbs whose root contains one or more weak letters. Based on the position of the weak letter (i.e. alef (أ), waw (و), or yaa (ي)), the verb can be further classified into the following three subclasses: first weak (called Paradigm), second weak (called Hollow), third weak (called Defective).

[6] stated that weak verbs can be categorized into three subclasses depending on the position of the weak letter in the root: mithal (aka first weak) (مثال), hollow (aka middle weak) (أجوف), and defective (aka last weak letter) (ناقص). A fourth weak verb is the enfolding (لفيف) verb that contains two possible cases of weak letters: middle and final or first and final weak letters. Verbs can be further sub-categorized by tense (past, present and future), case (nominative, accusative and genitive), with respect to transitivity (intransitive and transitive), aspect (perfective, imperfective and imperative), with respect to the subject (person, number and gender) and, voice (active and passive).

This study attempted to examine the implications of using VSO and SVO word order and the agreement requirement with irregular verbs in machine translation.

Corbett (2001) defined agreement as "systematic covariance between a semantic or formal property of one element and a formal property of another.", he used the terms "controller" to refer to the element which determines the agreement, "target" to refer to the element whose form is determined by agreement, and "domain" to refer to the syntactic environment in which agreement occurs [30][16][37].

Attia (2008) stated that Arabic has rich agreement morphology which allows it to show agreement relations between various elements in the sentence.
There are five morpho-syntactic features involved in agreement in Arabic: number (singular, dual and plural), gender (feminine and masculine), person (1st 2nd, and 3rd), case (nominative, accusative and genitive) and definiteness (definite and indefinite) [14].

Noun-adjective shows strongest agreement where four of the five agreement features are involved: number,

3 (Shaalan, 2005)
4 (K., 2005)
5 (Belkredim., 2009)
6 (Shaalan. K., 2009)

gender, case and definiteness, second strongest agreement are the pre-verbal position subject where verbs are required to agree with their subjects in number, gender and person, thus it is clear that there is a strong correlation between word order and verbal agreement in Standard Arabic (SA), i.e. full agreement in SVO order and partial agreement in VSO order.

Al-Jarf (2007) categorised the need to use VSO word order against the use of VSO word order as follows: SVO structures are used mostly in (nominal sentences and clauses):

(i) sentences consisting of a subject and a predicate.
(ii) sentences beginning with emphatic آنّ .
(iii) sentences beginning with auxiliary كان.
(iv) sentences beginning with the negative particle لا.
(v) after ظنّ 'thought' group.
(vi) after قال 'said'.
(vii) after أخبر 'told' and أرى 'showed'
(viii) in answer to certain interrogatives.

On the other hand, VSO structures are used mostly in (verbal sentences):

(i) Conditional sentences beginning with certain particles.
(ii) When independent subject pronouns are deleted. Independent pronoun usage in subject position is discourse-based.
(iii) After sentence initial adverbials and prepositional phrases,
(iv) in passive clauses ([24][5]).

Al-Jarf (2007) added "Although word order has been found to constitute a major difficulty in translation, studies that analyze SVO errors and VSO errors in English-Arabic translation are lacking" [8]. She then attempted to examine the nature of transfer of SVO word order from English. Semantically speaking, the SVO pattern gives emphasis to the subject, whereas the VSO pattern gives emphasis to the verb, the choice between VSO and SVO in Arabic is related to syntactic, pragmatic, discoursal discourse and semantic factors available in a particular context [4] She concluded that the Mastery of SVO and VSO structures in English-Arabic translation can be achieved by improving translation instruction

Al-Momani (2010) explored the word ordering phenomena in a free word order language like Arabic. He concluded that Arabic is a non-configurational language because it exhibits high word order freedom (i.e. it allows multiple word order permutations). He added, Arabic has the SVO word order as an alternative order and the alternation is conditioned by discourse and semantic features. Thus, the choice between these two orders is triggered by prior information in the discourse. If an entity has not been mentioned before, then the VSO order is preferred; whereas, if an entity has been mentioned before, then the SVO order is necessary [10].

Essentially, the Arabic word can be described as follows:

[prefix1][prefix1] stem [infixes] [suffix1] [suffix2] [12]

The stem (morpheme) is the minimal meaning-bearing unit in a language. Affixes in Arabic can be categorized into three types, the prefixes, suffixes (or postfixes) and infixes [33]. The prefixes are added at beginning of the stem and the suffixes are added at the end of stem, whereas, the infixes are inserted inside the stem. Table 11 below shows some examples of the affixes handling.

Table 11Table 11 An Arabic affixes/suffixes handling examples.

suffixes2	suffixes1	infixes	stem	Prefixes2	prefixes1	Arabic word	Structure
-	-	-	ضرب	-	-	ضرب	$C_1aC_2aC_3a$
-	-	-	ضرب	يـ	-	يضرب	$yaC_1C_2iC_3u$
-	-	ا	ضرب	يـ	-	يضارب	$yuC_1AC_2iC_3u$
هم	-	-	ضرب	يـ	-	يضربهم	$yaC_1C_2iC_3uhum$
هم	-	-	ضرب	يـ	س	سيضربهم	$syaC_1C_2iC_3uhum$
هم	-	ا	ضرب	يـ	س	سيضاربهم	$syuC_1AC_2iC_3uhum$
هم	ون	ا	ضرب	يـ	س	سيضاربونهم	$syuC_1AC_2iC_3unahum$

Suffixes in Arabic can be categorized into two basic categories, the suffixes that are attached to the verbs and the suffixes that are added to the nouns [39]. Furthermore, some of the suffixes can be attached to both the noun and verb stem. Nevertheless, Arabic permits the use of up to three suffixes simultaneously to be attached to the end of the same stem [1]. Furthermore, Arabic words are built from roots rather than stems and involve diacritization. Written Arabic is also characterized by the inconsistent and irregular use of punctuation marks [14]. Table-12 below presents a wide range of suffixes example for the verb hit (ضرب).

Table 12 Arabic suffixes examples (adopted from Abu Shquier. M and Abu Shqeer. O 2012) [5]

Suffix	Suffix description	Suffix category Verb/Noun/Both	Example	phonetics

ني	first person	Verb	ضربني	drbny
ك	addresser singular	Both	ضربك	drbk
هـ	absent masculine singular	Both	ضربه	drbh
ها	absent feminine singular	Both	ضربها	drbha
هم	absent masculine plural	Both	ضربهم	drbhm
هن	absent feminine plural	Both	ضربهن	drbhn
هما	absent dual	Both	ضربهما	drbhma
كم	addresser masculine plural	Both	ضربكم	drbkm
كن	addresser feminine plural	Both	ضربكن	drbkn
كما	addresser masculine dual	Both	ضربكما	drbkma

As for traditional Arab grammarians, VSO is the normal syntactic word order. According to generative grammar, VSO is the basic word order and SVO is derived through subject movement. VSO order is unmarked for focus, emphasis and information distribution. The SVO pattern gives emphasis to the subject, whereas the VSO pattern gives emphasis to the verb [4].

3. Proposed Model

It is clear from the previous section that VSO and SVO words ordering plays a crucial role in the translation process. The subsequent examples in tables 13 through 30 show different agreement requirements between the irregular verbs and their subjects depending on whether VSO or SVO words ordering are used. The selection of using VSO or SVO related to the context where we use SVO whenever the subject is our focus.

Table 13 Example 1 (Third person subjects with different genders and numbers with doubled verb repeated ردّ)

		a	b	c	d
English		The girls **repeated** the sentence	The girl **repeated** the sentence	The boys **repeated** the sentence	The boy **repeated** the sentence
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات **ردَدْنَ الجملة**	البنت **ردّت الجملة**	الاولاد **ردّدوا الجملة**	الولد **ردّد الجملة**
	Structure	$C_1aC_2C_2aC_3$**na**	$C_1aC_2C_2$**at**	$C_1aC_2C_2aC_3$**uu**	$C_1aC_2C_2aC_3$**a**
	Agr.	Number, gender, and person			
VSO	Arabic	**ردّت البنات الجملة**	**ردّت البنت الجملة**	**ردّد الاولاد الجملة**	**ردّد الولد الجملة**
	Structure	$C_1aC_2C_2aC_3$**at**	$C_1aC_2C_2aC_3$**at**	$C_1aC_2C_2aC_3$**a**	$C_1aC_2C_2aC_3$**a**
	Agr.	Gender and person			

Table 14 Example 2 (First person subjects with different numbers with doubled verb repeated ردّ)

		a	b
English		We **repeated** the sentence	I **repeated** the sentence
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن رددنا الجملة	انا رددت الجملة
	Structure	$C_1aC_2C_2aC_3$**naa**	$C_1aC_2C_2aC_3$**tu**
	Agr.	Number and person	
VSO	Arabic	رددنا الجملة	**رددت الجملة**
	Structure	$C_1aC_2C_2aC_3$**naa**	$C_1aC_2C_2aC_3$**tu**
	Agr.	Number and person	

It is clear from example-1 that verbs have full agreement with their third person subjects, as they are supposed to agree with their subjects in number, gender and person when SVO is used; contrastively when VSO is used, verbs have partial agreement, as they agree with their subjects in gender and person only; while they remain intact with both singular and plural subjects. At the same time, example-2 shows that in both modes (SVO and VSO) the same rules of agreement (number and person) have been applied between verbs and subjects regardless of the gender when the subject is a first person. With more examples, we can show that a lot of agreement variations exist between verb and subject according to the subject features (gender, person, and number), verb tense (past, present, and imperative), and verb-subject order (SVO and VSO).

Table 15 Example 3 (Third person subjects with different genders and numbers with hamzated past verb read قرأ)

		a	b	c	d
English		The girls **read** the sentence	The girl **read** the sentence	The boys **read** the sentence	The boy **read** the sentence
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات **قرأن الجملة**	البنت **قرأت الجملة**	الاولاد **قرؤوا الجملة**	الولد **قرأ الجملة**
	Structure	$C_1aC_2aC_3$**ana**	$C_1aC_2aC_3$**at**	$C_1aC_2aC_3$**uu**	$C_1aC_2aC_3$**a**
	Agr.	Number, gender, and person			
VSO	Arabic	**قرأت البنات الجملة**	**قرأت البنت الجملة**	**قرأ الاولاد الجملة**	**قرأ الولد الجملة**
	Structure	$C_1aC_2aC_3$**at**	$C_1aC_2aC_3$**at**	$C_1aC_2aC_3$**a**	$C_1aC_2aC_3$**a**
	Agr.	Gender and person			

Table 16 Example 4 (First person subjects with different numbers with hamzated past verb read قرأ)

		a	b
English		We **read** the sentence	I **read** the sentence
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن قرأنا الجملة	انا قرأت الجملة
	Structure	$C_1aC_2aC_3$**anaa**	$C_1aC_2aC_3$**atu**
	Agr.	Number and person	
VSO	Arabic	**قرأنا الجملة**	**قرأتُ الجملة**
	Structure	$C_1aC_2aC_3$**anaa**	$C_1aC_2aC_3$**atu**
	Agr.	Number and person	

Table 17 Example 5 (Third person subjects with different genders and numbers with hamzated present verb read يقرأ)

		a	b	c	d
English		The girls **read** the sentence	The girl **reads** the sentence	The boys **read** the sentence	The boy **reads** the sentence
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات **يقرأن الجملة**	البنت **تقرأ الجملة**	الاولاد **يقرؤون الجملة**	الولد **يقرأ الجملة**
	Structure	**ya**$C_1C_2aC_3$**ana**	**ta**$C_1C_2aC_3$**u**	**ya**$C_1C_2aC_3$**uun**	**ya**$C_1C_2aC_3$**u**
	Agr.	Number, gender, and person			
VSO	Arabic	**تقرأ البنات الجملة**	**تقرأ البنت الجملة**	**يقرأ الاولاد الجملة**	**يقرأ الولد الجملة**

	Structure	**ta**C_1C_2**a**C_3**u**	**ta**C_1C_2**a**C_3**u**	**ya**C_1C_2**a**C_3**u**	**ya**C_1C_2**a**C_3**u**
	Agr.	Gender and person			

Table 18 Example 6 (First person subjects with different numbers with hamzated present verb read يقرأ)

		a	b
English		We **read** the sentence	I **read** the sentence
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن نقرأ الجملة	انا أقرأ الجملة
	Structure	naC_1C_2aC_3u	?aC_1C_2aC_3u
	Agr.	Number and person	
VSO	Arabic	**نقرأ الجملة**	**أقرأ الجملة**
	Structure	naC_1C_2aC_3u	?aC_1C_2aC_3u
	Agr.	Number and person	

Table 19 Example 7 (Third person subjects with different genders and numbers with Methal verb describe يصف)

		a	b	c	d
English		The girls **describe themselves**	The girl **describes herself**	The boys **describe themselves**	The boy **describes hemself**
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات يصفن انفسهنّ	البنت تصفُ نفسها	الاولاد يصفون أنفسهم	الولد يصف نفسه
	Structure	yaC_2iC_3na	taC_2iC_3u	yaC_2iC_3una	yaC_2iC_3u
	Agr.	Number, gender, and person			
VSO	Arabic	تصفُ البنات انفسهن	تصفُ البنت نفسها	يصفُ الاولاد انفسهم	يصفُ الولد نفسة
	Structure	taC_2iC_3u	taC_2iC_3u	yaC_2iC_3u	taC_2iC_3u
	Agr.	Gender and person			

Table 20 Example 8 (First person subjects with different numbers with Methal verb describe يصف)

		a	b
English		We **describe ourselves**	I **describe myself**
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن نصفُ انفسنا	انا اصفُ نفسي
	Structure	naC_2iC_3u	?aC_2iC_3u
	Agr.	Number and person	
VSO	Arabic	**نصفُ انفسنا**	**اصفُ نفسي**
	Structure	**na**C_2**i**C_3**u**	**?a**C_2**i**C_3**u**
	Agr.	Number and person	

Table 21 Example 9 (Third person subjects with different genders and numbers with hollow verb said قال)

		a	b	c	d
English		The girls **said…**	The girl **said…**	The boys **said…**	The boy **said…**
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات قلنَ	البنت قالت	الاولاد قالوا	الولد قال
	Structure	C_1uC_3na	$C_1aC_2C_3$at	$C_1aC_2C_3$uu	$C_1aC_2C_3$a
	Agr.	Number, gender, and person			
VSO	Arabic	قالت البنات	قالت البنت	قال الاولاد	قال الولد
	Structure	$C_1aC_2C_3$at	$C_1aC_2C_3$at	$C_1aC_2C_3$a	$C_1aC_2C_3$a
	Agr.	Gender and person			

Table 22 Example 10 (First person subjects with different numbers with hollow verb said قال)

		a	b
English		We **said….**	I said….
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن قلنا	انا قلت
	Structure	C_1uC_3naa	C_1uC_3tu
	Agr.	Number and person	
VSO	Arabic	**قلنا**	**قلتُ**
	Structure	C_1**u**C_3**naa**	C_1**u**C_3**tu**
	Agr.	Number and person	

Table 23 Example 11 (Third person subjects with different genders and numbers with defective verb threw رمى)

		a	b	c	d
English		The girls **threw the stone**	The girl **threw the stone**	The boys **threw the stone**	The boy **threw the stone**
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات رمينَ الحجر	البنت رمت الحجر	الاولاد رموا الحجر	الولد رمى الحجر
	Structure	$C_1aC_2aC_3$na	C_1aC_2at	$C_1aC_2uC_3$u	$C_1aC_2aC_3$a
	Agr.	Number, gender, and person			
VSO	Arabic	رمت البنات الحجر	رمت البنت الحجر	رمى الاولاد الحجر	رمى الولد الحجر
		C_1aC_2at	C_1aC_2at	$C_1aC_2aC_3$a	$C_1aC_2aC_3$a
	Agr.	Gender and person			

Table 24 Example 12 (First person subjects with different numbers with defective verb threw رمى)

		a	b
English		We **threw the stone.**	I threw the stone
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن رمينا الحجر	انا رميت الحجر
	Structure	$C_1aC_2aC_3$na	$C_1aC_2aC_3$tu
	Agr.	Number and person	
VSO	Arabic	**رمينا الحجر**	**رميت الحجر**
	Structure	C_1**a**C_2**a**C_3**na**	C_1**a**C_2**a**C_3**tu**
	Agr.	Number and person	

the verb threw (رمى) is originally came from the root-form (رَمَيَ) because when we use it with 3rd masculine singular present tense it would be to throw (يرمي), while it is with 3rd masculine plural present tense would be (يرموا). In the table above we have seen that the 3rd root letter (C_3) has been omitted when conjugated with 3rd feminine singular (s,f,3) in both SVO and VSO word order, however, when we conjugated the verb with (p,m,f), the 3rd root letter has been transformed to 'w' when using SVO word order, e.g., الاولاد رموا الحجر. Nevertheless, the 3rd root letter has been transformed back to ى with (s,m,3) conjugation in VSO word order.

On the other hand, when we use the VSO word order, the 3rd root letter will be omitted when conjugating with both (p,f,3) and (s,f,3), while it will be transformed to ى when conjugating with both (p,m,3) and (s,m,3).

Table 25 Example 13 (Third person subjects with different genders and numbers with enfolding verb saw رأى)

		a	b	c	d
English		The girls saw the paper	The girl **saw the paper**	The boys **saw the paper**	The boy **saw the paper**
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات رأين الورقة	البنت رأت الورقة	الاولاد رأوا الورقة	الولد رأى الورقة
	Structure	$C_1aC_2aC_3na$	C_1aC_2at	$C_1aC_2aC_3u$	$C_1aC_2aC_3a$
	Agr.	Number, gender, and person			
VSO	Arabic	رأت البنات	رأت البنت	رأى الاولاد	رأى الولد
	Structure	C_1aC_2at	C_1aC_2at	$C_1aC_2aC_3a$	$C_1aC_2aC_3a$
	Agr.	Gender and person			

Table 26 Example 14 (First person subjects with different numbers with enfolding verb saw رأى)

		a	b
English		We **saw the paper**	I saw the paper
Subject		we (p, -, 1)	I (s, -, 1)
SVO	Arabic	نحن رأينا الورقة	انا رأيتُ الورقة
	Structure	$C_1aC_2aC_3na$	$C_1aC_2aC_3tu$
	Agr.	Number and person	
VSO	Arabic	رأينا	رأيتُ
	Structure	$C_1aC_2aC_3na$	$C_1aC_2aC_3tu$
	Agr.	Number and person	

Other features such as humanity and animate also should be considered [3]. Examples 3 and 4 below show how the humanity feature affects the agreement requirements; it is clear from example-3 that in both modes SVO and VSO the gender and person agreements are maintained with non-human feminine subject, while only the person agreement is maintained with masculine subject; whereas in both genders the singular form of the verb is used; observe that a feminine singular verb is used with masculine plural subject as it is appear in 3.c. The story is differ with human being subject, in SVO words order; number, gender, and person agreements are maintained between the verb and the subject; while in VSO words order; gender and person agreements are maintained, whereas the verb is in singular form regardless of the subject number (singular or plural).

In the same way we can show that different agreement rules are needed with animate/inanimate subjects, with dual (two persons) subject, with more than one subject in the same sentence e.g. "the boy and the girls play football", and also with more than one verb such as "The women eat and speak", and so on.

Table 27 Example 15 (Non-human subjects with different genders and numbers)

	a	b	c	d
English	The cats **drink** milk	The cat **drinks** milk	The camels **eat** grass	The camel **eats** grass
Subject	cats (p, f, 3)	cat (s, f, 3)	camels (p, m, 3)	camel (s, m, 3)
SVO Arabic	القطط **تشرب** الحليب	القطة **تشرب** الحليب	الجمال **تأكل** العشب	الجمل **يأكل** العشب
SVO Structure	$taC_1C_2aC_3u$	$taC_1C_2aC_3u$	$taC_1C_2aC_3u$	$yaC_1C_2aC_3u$
SVO Agr.	Gender and person		Person	
VSO Arabic	**تشرب** القطط الحليب	**تشرب** القطة الحليب	**تأكل** الجمال العشب	**يأكل** الجمل العشب
VSO Structure	$taC_1C_2aC_3u$	$taC_1C_2aC_3u$	$taC_1C_2aC_3u$	$yaC_1C_2aC_3u$
VSO Agr.	Gender and person		Person	

Table 28 Example 16 (Human subjects with different genders and numbers)

		a	b	c	d
English		The girls **drink** milk	The girl **drinks** milk	The boys **drink** milk	The boy **drinks** milk
Subject		girls (p, f, 3)	girl (s, f, 3)	boys (p, m, 3)	boy (s, m, 3)
SVO	Arabic	البنات **يشربن** الحليب	البنت **تشرب** الحليب	الاولاد **يشربون** الحليب	الولد **يشرب** الحليب
	Structure	$yaC_1C_2aC_3na$	$taC_1C_2aC_3u$	$yaC_1C_2aC_3una$	$yaC_1C_2aC_3u$
	Agr.	Number, gender, and person			
VSO	Arabic	**تشرب** البنات الحليب	**تشرب** البنت الحليب	**يشرب** الاولاد الحليب	**يشرب** الولد الحليب
	Structure	$taC_1C_2aC_3u$	$taC_1C_2aC_3u$	$yaC_1C_2aC_3u$	$yaC_1C_2aC_3u$
	Agr.	Gender and person			

Two important questions emerge, the first one: is it possible to generate all different derivations of the verb for all verbs by following a fixed set of rules? If we neglect the irregular cases, the answer is yes; but we know that nobody can ignore them, therefore we need to build all possible rules and manipulate the irregular cases in a different way such as maintaining an example-based database for them and consult it beside the rules database. The second question is: how the translator will decide when to use SVO and when to use VSO since the decision depends on which is our focus: the verb or the subject? It is not easy to answer this question, but in our opinion the translator should use the mostly used mode (VSO) as a default, and modify some sentences to (SVO) according to a semantic analysis of the source text. Figure-1 below illustrates a proposed model to achieve this. The following is an explanation of the model processes with example:

Process 1: Receives the source text (English statement), and pass it to the parser;

(The girls saw the paper).

Process 2: Identifies POS by consulting the English grammar database table:

(The/DT girls/NNS saw/VBD the/DT paper/NN).

Process 3: Retrieves Arabic meanings as well as subject features from the English lexicon database table;

(The/ ال girls/ بنات saw/ رأت the/ ال paper/ ورقة);

(girls/ plural, feminine, and 3rd person).

Process 4: Analyzes the source text semantically to decide whether SVO should be used or not;

(The result will be either yes or no).

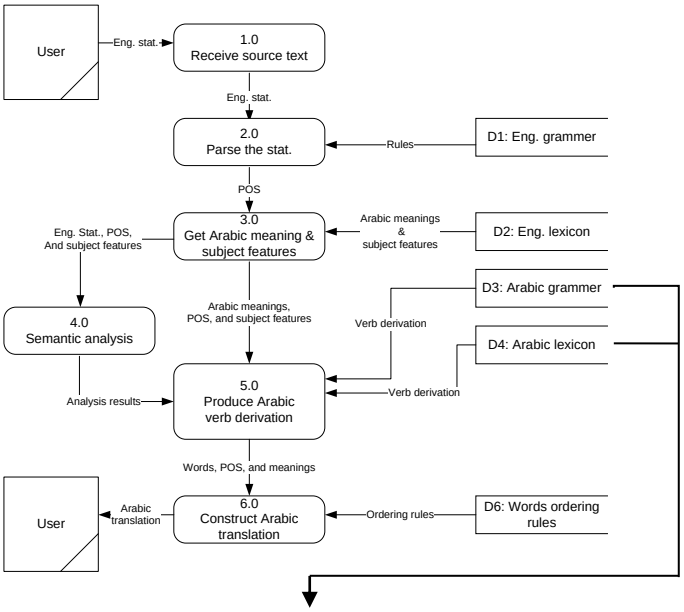
Process 5: Creates the correct derivation of the equivalent Arabic regular verbs depending on the

results from processes 3 and 4, and the consultation of the Arabic grammar, Arabic lexicon.

Process 6: Creates the correct derivation of the equivalent Arabic irregular verbs depending on the result of the 30 cases shown in the figure below and from processes 3 and 4, and the consultation of the Arabic grammar, Arabic lexicon.
(If the result of process 4 is no, then the verb will be رَأت (C_1aC_2at) since the default mode VSO will be used; if the result is yes, the verb will be رأينَ ($C_1aC_2aC_3na$) since SVO mode will be used).

Process 7: Finally, the complete Arabic translation is produces by referencing the words ordering rules database table:

(based on the result of the previous processes, we will get either رأت البنات الورقة "ra?at albnat alwaraqah" in the case of using VSO or البنات رأينَ الورقة"albnat ra?aina alwaraqah" in the other case SVO).



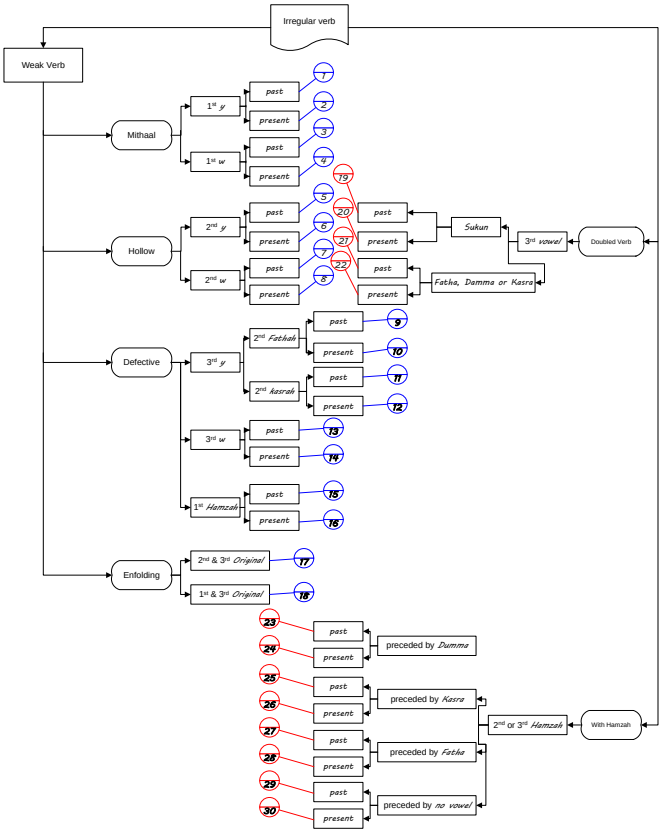


Figure 1 Level 0 DFD of the proposed model

Figure 1 explores the verb derivation process conducted in EA-HBMT, we first determine whether the verb is regular or not, if it is regular then we proceed to the next step, otherwise we check whether the irregular verb is weak, doubled or hamzated (with hamzah) verb. If the verb is weak then we have to further check how weak is that verb, i.e, Mithal, Hollow, defective, or enfolding. Actually we have labeled each of the derivational cases with a number to represent the action behind that case. For instance number 3 represents the behavior of the irregular weak mithal past tense-verb whose 1st root letter is the (long vowel و), based on the number, gender, tense and person, we will define the following table that represents what suffixes/infixes are to be added to the verb according to the rule [prefix1][prefix1] stem [infixes] [suffix1] [suffix2]. Let us explore this rule by taking the verb (described وصف)

Table 29 Example 17 derivation of rule 3 of the irregular weak mithal past tense-verb whose 1st root letter is the (long vowel و)

	Singular	Dual	Plural
	Past	Past	Past
1st - Masc	وصفتُ ($C_1aC_2aC_3tu$)	وصفنا ($C_1aC_2aC_3na$)	وصفنا ($C_1aC_2aC_3na$)
1st - Fem			
2nd – Masc	وصفتَ ($C_1aC_2aC_3t$)	وصفتما ($C_1aC_2aC_3tuma$)	وصفتم ($C_1aC_2aC_3tumm$)
2nd - Fem	وصفتِ ($C_1aC_2aC_3ti$)		وصفتنَ ($C_1aC_2aC_3tumaa$)
3rd – Masc	وصفَ ($C_1aC_2aC_3a$)	وصفا ($C_1aC_2aC_3aa$)	وصفوا ($C_1aC_2aC_3u$)
3rd – Fem	وصفَت ($C_1aC_2aC_3at$)	وصفتا ($C_1aC_2aC_3ataa$)	وصفن ($C_1aC_2aC_3naa$)

Table 29 shows regularity in the past tense but the case is different with present.
Let us now explore the behavior of the irregular weak mithal present tense-verb whose 1st root letter is the (long vowel و). Table 30 below represents the entire behavior

Table 30 Example 18 (Human subjects with different genders and numbers)

	Singular	Dual	Plural
	Present	Present	Present
1st - Masc	اصِفُ (ʔC2iC3u)		نصِفُ (naC2iC3u)
1st - Fem			
2nd – Masc	تصِفُ (taC2iC3u)	تصفان (taC2iC3an)	تصفون (taC2iC3un)
2nd - Fem	تصِفِ (taC2iC3i)		تصفن (taC2iC3na)
3rd – Masc	يصِفُ (yaC2iC3u)	يصفان (yaC2iC3an)	يصفون (yaC2iC3un)
3rd - Fem	تصِفُ (taC2iC3u)	تصفان (taC2iC3an)	يصفن (yaC2iC3na)

We have seen here that irregular weak mithal present tense-verb whose 1st root letter is the (long vowel و) lost their first original letter (the weak letter) (C_1) in all cases.

4. Conclusion

This research has dealt with irregular verb derivation in English-Arabic Machine Translation in conjugation with sentence word order. Through this paper we have explored the characteristics of Arabic language that will affect the development of a Machine Translation (MT). Several distinguishing features of Arabic pertinent to irregular verbs have been explored in detail with reference to some potential difficulties that they might present.

The recent study attempted to examine the nature of using VSO and SVO word order with irregular verbal sentences. This paper investigates different rules to manage the problem of morphological and syntactic ambiguities in Arabic that arisen due to the richness and complexity of Arabic morphology.
Arabic as a Target Language (TL) in this paper is highly inflectional, rich morphology and relatively free word's order language; it allows the combinations of SVO, VSO, VOS and OVS.

We concluded that we can enhance the output quality of English-Arabic MT by feeding the system with adequate, robust and completed rules to deal with the morph-syntactic inflectional morphological features of irregular verbs. To achieve this task we proposed a set of 30 rules based on the tense of the verb, place of the vowel root letter, first, second or third person representation, number and gender features, and diacritics preceding vowel letter, i.e., nominative, accusative or genitive case.

Through the investigation of the available MTs and related researches, as well as the flexibility of Arabic language grammars, we concluded that we are a bit far away from getting an English-Arabic MT up to the accuracy of human translation due to either faulty analysis of the SL text or faulty generation of the TL text.

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