

Thematic Roles-Based Translation in MT Systems

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Abstract— The main purpose of this paper is to identify a particular thematic roles inventory that can improve the product of machine translation systems. Thematic role relations are among the semantic relations that can disambiguate the meaning of a considerable number of lexical items. Some verbs, for instance, are ambiguous for MT systems and hence are not accurately translated. The meaning of such verbs can be disambiguated by identifying the thematic role relations of their predicates. For example, ‘to express’ has two different meanings depending on its thematic role relations of its Predicate. When the verb assigns Patient <liquid> for its Object, it means ‘to squeeze out’, e.g., ‘Italians express coffee’. When it assigns Theme <letter> or <package> for its Object, it has the meaning of ‘sending by rapid transport’, e.g., ‘She expressed the letter to Florida’. The present research will focus only on a group of English verbs that convey a variety of meanings. It will show several problems in the translation of sample verbs due to the lack of thematic roles in the core of the system. The implementation is made on three MT systems: Al Wafi, Sakhr and Google. They all produce incorrect translations of the sample verbs. A suggested translation is proposed for each verb after analyzing its thematic roles and selectional restrictions.

Keywords— Machine Translation, Semantic Relations Thematic Roles.

I. INTRODUCTION

A catchall definition of thematic roles can be set as the semantic relations that hold between the verb and the different arguments that can be assigned to this verb. However, they cannot be described in semantic terms only, as Dowty assumes they are “creatures of syntax-semantics interface, and thus require a sound semantic theoretical basis as well as a syntactic one ...” (Dowty1991:548). Thematic roles have developed through different linguistic stages starting from Gruber (1965), who introduced the concept using the term *thematic relations*, and Government and Binding theory (GB) in which thematic relations were introduced in a pure syntactic form as Theta Roles. Then the term was developed into a different semantic concept by Jackendoff (1972) who called these semantic relations ‘Thematic Relations’. However, thematic relations can be described as corresponding to Fillmore’s *Deep Cases* that were introduced in the structure of his Case Grammar (Fillmore, 1968). The present research

deals with the concept using the term Thematic Roles. It also avails of what Dowty calls Thematic Proto Roles (Dowty, 1991).

II. CRITERIA OF SAMPLE VERBS

The choice of successful samples is mainly based on the verb’s ability to assign thematic roles and whether it is possible to map the deep structure to the surface structure of the nominal arguments. For a sample to be successful, some criteria should be followed. First, the sample should be a verb. The scope is limited to verbs only since they are the predicates that assign the thematic roles. Second, it does not, however, deal with all verbs in English. The focus is on the verbs that can convey a variety of meanings. Such verbs may cause some sort of ambiguity during translation and need to be disambiguated. Third, the successful sample verbs indicate that each verb can assign different thematic roles. The diversity of roles is supposed to lead to different translations of the same verb. On the contrary, the unsuccessful sample verbs indicate that each verb bears a single role and hence has a single meaning or translation. In this case, there is no need to conduct such an analysis since there would not be ambiguity in the translation of verbs with single roles.

III. THEMATIC ROLE-BASED TRANSLATION

The significance of developing thematic roles for MT systems lies in the fact that thematic roles are not merely semantic but rather conceptual relations that hold between the predicate and its arguments (Wagner, 2005). MT systems generally fail to produce proper translation in such cases that need thematic- role- based disambiguation. Successful sample verbs are presented in different sentences. Each sentence will be submitted to translation into Arabic via three MT systems; Al Wafi, Google and Sakhr. The outcome translations show mistranslated parts. A suggested successful translation is proposed for each verb in each sentence. It is, simply, a presentation of how each sample verb would be correctly translated if the thematic roles (along with the selectional restrictions) were added.

The following examples present the transitive verb break with two meanings: to cause to separate or divide into pieces and to breach or violate. However, the translation of each sentence produced by the three MT systems does not differentiate between these two distinct meanings.

Sample verb	Sample sentences	Translations
1- Break	1.1 <i>He broke the glass plate.</i>	Al Wafi: كسر الصحن الزجاجي Google: حطم اللوحة الزجاجية Sakhr: كسر طبق الزجاج
	1.2 <i>The ball broke the window.</i>	Al Wafi: كسرت الكرة النافذة Google: كسرت النافذة الكرة Sakhr: كسرت الكرة النافذة
	1.3 <i>She broke the law.</i>	Al Wafi: كسرت القانون Google: كسرت القانون Sakhr: خرقت القانون Proposed translation: خرقت القانون
	1.4 <i>They broke the contract.</i>	Al Wafi: كسروا العقد Google: كسروا العقد Sakhr: كسروا العقد Proposed translation: خرّفوا العقد

Table (1): Translations of the verb 'break'.

It seems that the MT system may recognize only one meaning of the transitive form of the verb *break*: *to cause to separate or divide into pieces*. In 1.1 *He broke the glass plate* and 1.2 *The ball broke the window*; the three systems deal with the verb *break* as having the meaning *to cause to separate or divide into pieces*. In this context, the verb assigns an Agent <Animate> for its Subject and a Patient <Physical entity> for its Object. As such, it has the meaning *to cause to separate or divide into pieces*. The successful translation of *break* in such a context is 'كسر'. This successful translation is produced by the three MT systems. However, the same translation 'كسر' cannot be adopted for the same verb *break* in contexts where it assigns Agent <Animate> for its Subject but Theme <Legal Agreement> for its Object. The change in the thematic roles turns *break* to mean *breach or violate*. As such, it should be translated into 'خرق' not 'كسر'. In 1.3 *She broke the law*, both Al Wafi and Google keep the same understanding of the verb and produce the same translation which is mistranslation in this context. On the other hand, Sakhr succeeds in producing the proper translation 'خرق'. It cannot be assumed that Sakhr is fed with the right logic that produces the proper translation for *break* and other similar verbs. In 1.4 *They broke the contract*, Sakhr fails in producing the proper translation of *break* in a similar context where the verb assigns Agent <Animate> for its Subject but Theme <Legal Agreement> for its Object. This means that the system lacks the right logic to produce the right translation. It is proposed here that thematic roles and selectional restrictions are the most fundamental base for successful translation of ambiguous verbs.

Sample verb	Sample sentences	Translations
2- Clap	2.1 <i>The big bird clapped its wings.</i>	Al Wafi: صفق الطير الكبير اجنحته Google: صفق الطائر بجناحيه كبيرة Sakhr: الطائر الكبير صفق أجنحته

		Proposed translation: رفرر الطير الكبير اجنحته
	2.2 <i>The children clapped their hands.</i>	Al Wafi: الأطفال صفقوا Google: صفق الأطفال أيديهم Sakhr: صفق الأطفال أيديهم

Table (2): Translations of the verb 'clap'.

The transitive verb *clap* in 2.1 assigns an Agent for its Subject. It imposes that such Agent should be <Bird>. For its Object, it assigns Theme <Wings>. In this context, *clap* means *to flap*. This meaning is not recognized by any of the three systems. They all mistranslate the verb in 2.1 into 'صفق' or *applaud*, whereas the proper translation in such context is *to flap* or 'رفرف' as it is presented in the proposed translation. In 2.2, the same verb *clap* assigns an Agent <Human> for its Subject and a Patient <Hands> for its Object. In this context *clap* means *to applaud*. It seems that only such context is recognized by the three MT systems.

Sample verb	Sample sentences	Translations
3- Cure	3.1 <i>The doctor cured the acne.</i>	Al Wafi: عالج الطبيب حب الشباب Google: الطبيب الشفاء من حب الشباب Sakhr: عالج الدكتور حب الشباب
	3.2 <i>These tablets cure the fever.</i>	Al Wafi: تعالج هذه الأقراص الحمى Google: هذه الأقراص علاج الحمى Sakhr: تعالج هذه الأقراص الحمى
	3.3 <i>They can cure meats.</i>	Al Wafi: هم يمكن أن يعالجوا اللحم Google: يمكن أن علاج اللحم Sakhr: يمكن أن يعالجوا اللحم Proposed translation: هم يمكن أن يحفظوا اللحم
4	3.4 <i>These chemicals can cure pickles.</i>	Al Wafi: هذه المواد الكيميائية يمكن أن تعالج المخللات Google: يمكن علاج هذه المواد الكيميائية المخللات Sakhr: يمكن أن تعالج هذه المواد الكيميائية المخللات Proposed translation: هذه المواد الكيميائية يمكن أن تحفظ المخللات

Table (3): Translations of the verb 'cure'.

In 3.1 and 3.2, the verb *cure* has the meaning *heal*. It assigns the same Theme and imposes the same selectional restrictions on its Object <Disease>. Although the Subject is Agent <Animate> in 3.1 *the doctor* and a Force <Inanimate> in 3.2 *tablets*, this does not affect the meaning of the verb. In this context *cure* is successfully translated into 'عالج' by Al Wafi and Sakhr. For Google, it also produces a proper translation 'يشف' despite the weak translation of the whole sentence. However, this does not mean that the three systems can keep the successful translation of the same verb in other

contexts where the verb changes the thematic roles and selectional restrictions. In 3.3 and 3.4, *cure* assigns Theme for its Object. However, it imposes that this Theme must be <Food> not <Disease>. In such a context *cure* means *preserve* rather than *heal*. Accordingly, it should be translated into 'حفظ'. Yet, the MT systems fail to produce this proper translation due to their inability to recognize the change in the selectional restrictions imposed on the Object.

Sample verb	Sample sentences	Translations
4- Cut	4.1 <i>Mary cut the rope.</i>	Al Wafi: قطع ماري الحبل Google: قطع حبل مريم Sakhr: قطع ماري الحبل
	4.2 <i>They cut cloth with scissors.</i>	Al Wafi: قطعوا قماشاً بالمقص Google: قطعوا القماش مع مقص Sakhr: قطعوا القماش بالمقص
	4.3 <i>The farmers will cut the grain.</i>	Al Wafi: المزارعون سيقطعون الحبوب Google: فإن المزارعين قطع الحبوب Sakhr: سيقطع المزارعون الحبوب Proposed translation: المزارعون سيحصدون الحبوب
	4.4 <i>They cut the wheat yesterday.</i>	Al Wafi: قطعوا الحنطة أمس Google: قطعوا القمح أمس Sakhr: قطعوا القمح أمس Proposed translation: حصدوا الحنطة أمس

Table (4): Translations of the verb 'cut'.

In 4.1 and 4.2, the verb *cut* as a transitive verb assigns an Agent <Animate> for its Subject and a Patient <Material> or <Cord> for its Object. In this context, *cut* means *to separate or divide with an instrument*. The three MT systems are fed with this context and produce the correct translation 'قطع'. Google presents alternative successful translations for cut such as 'قص', 'شق', and 'استأصل'. However, the same verb *cut* may change its meaning by changing the thematic roles it assigns for the Subject and Object. In 4.3 and 4.4, *cut* assigns an Agent <Animate> for its Subject and a Theme <Cereal Grass> for its Object. In this context, *cut* means *to harvest or reap*. However, the three systems are not able to disambiguate the meaning of the verb in this context. As such, they keep the same translation 'قطع' or 'قص' that is obviously incorrect. The proper translation should be 'حصد' as it is shown in the proposed translations in 4.3 and 4.4, but since the MT systems do not consider the thematic roles in their logic, they produce mistranslation in some contexts.

Sample verb	Sample sentences	Translations
5- Die	5.1 <i>She died from cancer.</i>	Al Wafi: ماتت من السرطان Google: توفيت من مرض السرطان Sakhr: ماتت من السرطان
	5.2 <i>My father died last year.</i>	Al Wafi: أبي مات السنة الماضية Google: توفي والدي العام

		الماضي Sakhr: مات أبي العام الماضي
5.3	<i>The car died on the road.</i>	Al Wafi: السيارة ماتت على الطريق Google: السيارة على الطريق Sakhr: ماتت السيارة على الطريق Proposed translation: السيارة تعطلت على الطريق
5.4	<i>My only computer died.</i>	Al Wafi: حاسوبي الوحيد مات Google: توفي جهاز الكمبيوتر الخاص بي فقط Sakhr: كمبيوترتي الوحيد مات Proposed translation: حاسوبي الوحيد تعطل

Table (5): Translations of the verb 'die'

In 5.1 and 5.2, the verb 'die' assigns Experiencer <Animate> for its Subject. Since it is an intransitive verb it has no Object. Thus, the disambiguation of the meaning of *die* depends on the thematic roles and restrictions it imposes on its Subject. In the context where it assigns an Experiencer <Aniamte> for its Subject, *die* means *perish* or *pass away*. Al Wafi and Sakhr successfully translate it into 'مات' and Google suggests more than one successful translation 'مات' or 'توفى'. However, in 5.3 and 5.4 where *die* assigns a Patient <Inanimate> for its Subject, it has the meaning of *stop* or *breakdown*. In this context the verb is mistranslated by the three systems which keep the same meaning of the verb die as in 5.1 and 5.2 *perish* or *pass away*. The proper translation is proposed, and *die* should be translated into *breakdown* or 'تعطل' rather than 'مات'.

The intransitive form of the verb *draw* may have two different meanings depending on the thematic roles it assigns for its Subject. In 6.1 *She is drawing*; the verb assigns an Agent and restricts it to <Human> only. In this context, *draw* means *to make drawings or create images*.

Sample verbs	Sample sentences	Translations
6- Draw	6.1 <i>She is drawing.</i>	Al Wafi: هي ترسم Google: فهي رسم Sakhr: تقترب
	6.2 <i>The patient's veins don't draw very easily.</i>	Al Wafi: عروق المريض لا تسحب بسهولة Google: أوردة المريض لا توجه بسهولة Sakhr: أورده المريض لا تقترب بسهولة Proposed Translation: أوردة المريض لا تنساب بسهولة

Table (6): Translations of the verb 'draw'.

Al Wafi provides the successful translation of the verb among other alternatives 'ترسم، تجتذب، تسحب، تلفت، تثير'. Google also can produce the successful translation of the verb *draw* in this context; 'رسم'. However, only Sakhr fails to provide the right translation. It translates *draw* into 'تقترب'. In 6.2 *the patient's veins don't draw easily*, the same intransitive form of the verb *draw* has a different meaning. It does not mean *make drawings or create images*. The verb assigns different

thematic roles for its Subject and hence its meaning is changed. In 6.2, the verb *draw* assigns a Theme for its Subject which is restricted to <Vessel> only. Thus, *draw* here does not mean *making drawings*. Vessels cannot make drawings or create images. In this context, *draw* means *to cause to flow a liquid*. However, the three MT systems fail to produce any successful translation of *draw* in this context. Al Wafi translates it into 'تسحب' and Google provides some alternatives such as 'توجة، تجذب، تتسحب'. Sakhr keeps the same translation 'تقترب' as in 6.1. However, it is proposed that the successful translation of *draw* where it assigns a Theme <Vessel> for its Subject should be 'تسيل' or 'تتناسب'.

In 7.1, the transitive verb *eat* is recognized by AL Wafi, Google and Sakhr as *take in solid food* and hence properly translated into 'اكل'. In this context, *eat* assigns an Agent <Animate> for its Subject and Patient <Food> for its Object. However, by changing the thematic roles, *eat* changes its meaning. In 7.2 and 7.3, the verb assigns Force <Chemical> or <Air> for its Subject and Patient <Inanimate> for its Object. Accordingly, the meaning is changed to be *corrode*, and the three MT systems cannot produce the successful translation.

Sample verb	Sample sentences	Translations
7- Eat	7.1 <i>She was eating a banana.</i>	Al Wafi: هي كانت تأكل موزة Google: وكانت يأكل موزة Sakhr: كانت تأكل موزة
	7.2 <i>The acid eats the surface of the machine.</i>	Al Wafi: ياكل الحامض سطح الماكينة Google: حمض يأكل سطح الجهاز Sakhr: يأكل الحمض سطح الماكينة Proposed translation: يصديء الحامض سطح الماكينة
	7.3 <i>The wind eats the metals.</i>	Al Wafi: تأكل الريح المعادن Google: الريح يأكل المعادن Sakhr: تأكل الريح المعادن Proposed translation: تصديء الريح المعادن

Table (7): Translations of the verb 'eat'.

The systems still deal with the verb *eat* as having the meaning of *take in solid food*. Al Wafi and Sakhr translate *eat* into 'اكل' and Google suggests the same translation as well as 'تتاول' which has the same meaning. However, the successful translation of *eat* in this context should be 'يصديء' rather than 'يأكل'.

In examples 8.1, 8.2, 4.3 and 8.4, the three MT systems deal with the verb *express* into having the meaning of *state* or *set forth in word*. Al Wafi translated *express* as 'بيدي', Google as 'أعرب' and Sakhr as 'عبر'. However, the analysis shows other two different meanings of *express*. In 8.1, the verb assigns Agent <Animate> for its Subject *Italians* and in 8.2, it assigns Force <Device>*machine*. In both examples, the verb assigns Patient <Liquid> for its Object. This limits the meaning of the verb to *press out* or *squeeze out*. It is worth mentioning here that although the three systems mistranslate the verb in this context, Google produces a near translation of the same verb *express* with *milk* as an object in the same context. It translates

express milk as 'شفط الحليب'. In addition, Al Wafi can recognize the meaning of *express* as *squeeze out* or 'عصر' with *milk* only rather than any other liquid. It translates *express milk* as 'يعصر الحليب'. As for Sakhr, it fails to produce successful translation of *express milk* at all. It translates it as 'عبر عن'. Moreover, the verb *express* has more meanings other than *state* or *squeeze*. In 8.3 and 8.4, the same verb *express* is translated by Al Wafi as 'ابدى' *state* or *set forth in words*, by Google as 'أعرب' and by Sakhr as 'عبر'.

Sample verb	Sample sentences	Translations
8- Express	8.1 <i>Italians express coffee.</i>	Al Wafi: يبدي الإيطاليون قهوة Google: أعرب الإيطاليون عن القهوة Sakhr: عبر الإيطاليون عن القهوة Proposed translation: يعصر الإيطاليون القهوة
	8.2 <i>The machine expresses grape juice.</i>	Al Wafi: تظهر الماكينة عصير عنب Google: الجهاز يعرب عن عصير العنب Sakhr: تعبر الماكينة عن عصير العنب Proposed translation: يعصر الجهاز عصير العنب
	8.3 <i>She expressed the letter to Florida.</i>	Al Wافي: أبدت الرسالة إلى فلوريدا Google: أعربت الرسالة إلى ولاية فلوريدا Sakhr: عبرت عن الخطاب إلى فلوريدا Proposed translation: أرسلت الرسالة إلى فلوريدا
	8.4 <i>They expressed the package to London.</i>	Al Wafi: أبدوا الرزمة إلى لندن Google: أعربوا عن حزمة لندن Sakhr: عبروا عن العرض إلى لندن Proposed translation: أرسلوا الرزمة إلى لندن

Table (8): Translations of the verb 'express'.

However, it means *send by rapid transport* since it assigns Agent <Human> for its Subject and Theme <Package> for its Object as previously shown in the analysis. The proper translation proposed in such context is 'ارسل' rather than 'أبدوا'. It is clear in 9.1 and 9.2 that the three MT systems produce the proper translation of the verb *gain* in such a context where the verb assigns Benefactive <Animate> for its Subject and a Theme <Abstract or Physical Entity> for its Object. The meaning of *gain* in this context is *acquire* or *win* and the proper translation is 'كسب' or 'اكتسب'. However, the systems keep the same translation for the same verb in 9.3 and 9.4 though they deal with the verb in a different context. In that context, the verb assigns an Agent <Animate> for its Subject, and Goal <Destination> or <Location> for its Object. The meaning of *gain* here is *reach* rather than *acquire* and the proper translation should be 'وصل' as shown in the proposed translation for 9.3 and 9.4.

Sample verbs	Sample sentences	Translations
9- Gain	9.1 <i>John gained a small fortune.</i>	Al Wafi: جون كسب ثروة لا بأس بها Google: اكتسب جون ثروة صغيرة Sakhr: كسب جون ثروة
	9.2 <i>She gained an understanding of international finance.</i>	Al Wafi: كسبت فهم المالية الدولية Google: اكتسبت فهم التمويل الدولي Sakhr: كسبت تفاهماً مالية دولية
5	9.3 <i>The swimmer gained the shore.</i>	Al Wafi: كسب السباح الشاطيء Google: حصل على السباح الشاطيء Sakhr: كسب السباح الشاطيء Proposed translation: وصل السباح إلى الشاطيء
	9.4 <i>The climber gained the top of the mountain.</i>	Al Wafi: كسب المتسلق قمة الجبل Google: اكتسب المتسلق قمة الجبل Sakhr: كسب المتسلق أعلى الجبل Proposed translation: وصل المتسلق إلى قمة الجبل

Table (9): Translations of the verb 'gain'.

In 10.1 and 10.2, it is not significant to consider the thematic roles assigned by the verb *pan* for its Subject since it does not affect the meaning of the verb. The fundamental roles that can help disambiguate the meaning of the verb *pan* are the roles assigned for the Object.

Sample verbs	Sample sentences	Translations
10- Pan	10.1 <i>He panned the fish after catching it.</i>	Al Wafi: السمك بعد panned هو مسكه Google: انتقادات أنه بعد اصطياد الأسماك منه Sakhr: انتقد السمك بعد إمساكه Proposed Translation: قلبي السمك بعد اصطياده
	10.2 <i>He panned the camera across the room.</i>	Al Wafi: آلة التصوير panned هو عبر الغرفة Google: انتقادات انه الكاميرا في جميع انحاء الغرفة Sakhr: انتقد الكاميرا عبر الحجره Proposed Translation: أدار الكاميرا عبر الغرفة

Table (10): Translations of the verb 'pan'.

6 In 10.1 *He panned the fish after catching it*, the verb assigns a Patient <Food> for its Object. In this context, *pan* means *to cook food in a pan*. However, Al Wafi cannot recognize the meaning of the past form of *pan*. Hence, the system transliterates the word rather than providing any translation of it. For more accuracy, the verb *pan* is inserted as Al Wafi in different forms *is panning, has panned, pans and pan*. The system keeps

transliterating the word in each case. However, it translates *pans* and *pan* as 'مقالي' and 'مقالة' which are still a mistranslation of the verb. Al Wafi deals with *pan* as a noun rather than a verb. On the other hand, Google and Sakhr, though dealing with *pan* as a verb, recognize the informal meaning of the verb. Both MT systems translate *pan* in 10.1 as 'انتقد'. It is the informal meaning of *pan* which is *to criticize or review harshly*. The proposed translation of the verb *pan* in this context where it assigns a Patient <Food> for its Object should be 'قلبي'. In 10.2, when *pan* changes its roles assigned for the Object, it changes its meaning. However, in 10.2 *He panned the camera across the room*, The three MT systems mistranslate the verb *pan*. Al Wafi cannot provide any translation of *pan*, whereas both Google and Sakhr keep the mistranslation 'انتقد'. Yet, *pan*, assigning a Theme <Camera> for its Object, means *to move the camera so as to follow a moving object*. Thus, the successful translation of *pan* is proposed in 10.2 as 'أدار' or 'حرك'. This meaning can be disambiguated by checking the thematic roles assigned by the verb on its Object rather than its Subject.

Sample verbs	Sample sentences	Translations
11- Read	11.1 <i>She reads well.</i>	Al Wafi: تقرأ حسناً Google: تقرأ جيداً Sakhr: تقرأ جيّداً
	11.2 <i>He is reading.</i>	Al Wafi: هو يقرأ Google: إنه يقرأ Sakhr: يقرأ
	11.3 <i>Her play reads better than it acts.</i>	Al Wafi: تقرأ مسرحيتها أفضل من تتصرف Google: مسرحيتها أفضل من يقرأ وهو يعمل Sakhr: تقرأ مسرحيتها أفضل مما يمثل
	11.4 <i>How does your new watch read?</i>	Al Wafi translation: كيف ساعتك الجديدة تقرأ؟ Google Translation: كيف تقرأ ساعتك الجديدة؟ Sakhr Translation: كيف تقرأ ساعتك الجديدة؟ Proposed translation: كيف تبدو ساعتك الجديدة؟

Table (11): Translations of the verb 'read'.

In 11.1 and 11.2, the three MT systems can produce the correct translation of the verb *read*. The systems deal with the verb in its usual sense *to interpret something that is written*. As such, 'read' is translated as 'يقرأ' in the context where it assigns an Agent <Animate> for its Subject. However, in 11.3 and 11.4, the same verb is mistranslated by the three MT systems. Al Wafi and Sakhr translate *read* as 'تقرأ', whereas Google provides more translations 'تقرأ' and 'تنص'. This can be due to the change in the thematic roles and selectional restrictions the verb assigns for its Subject in this context. In 11.3 and 11.4, the verb *read* assigns an Experiencer <Inanimate> for its Subject (*play* and *watch*). In this context,

read means to indicate or to show. However, the systems produce the same translation ‘يقرأ’ which is a mistranslation. The proper translation as proposed should be ‘يبدو’.

Sample verbs	Sample sentences	Translations
12- Scrub	12.1 <i>She scrubbed his back.</i>	Al Wafi: حكّت ظهره Google: هي نقيت ظهره Sakhr: نظّفت ظهره
	12.2 <i>She scrubbed the vacation plan.</i>	Al Wafi: حكّت خطة العطلة Google: هي نقيت العطلة خطة Sakhr: نظّفت خطة الإجازة
		Proposed translation: ألغت خطة العطلة

Table (12): Translations of the verb ‘scrub’.

When the verb *scrub* assigns an Agent <Animate> for its Subject and a Patient <Physical Entity> for its Object, it has the meaning *to rub*. In 18.1, Al Wafi translates *scrub* properly as the Arabic ‘حك’. Google provides ‘غسل’ and ‘نقى’ whereas Sakhr translates it as ‘نظف’. It seems that this is the only sense of the verb that the systems are fed with. Thus, in 18.2, the systems produce a mistranslation of the verb *scrub*. In this context, *scrub* assigns an Agent for its Subject. This Agent is limited to <Human> rather than <Animate>. For its Object, *scrub* assigns a Theme <Plan> or <Event>. In such context with Agent Subject and Theme Object, *scrub* cannot mean *to rub* but rather *to cancel*. The correct translation should be ‘ألغى’ not ‘حك’. The mistranslation is due to the fact that the MT systems are not able to recognize the change in the thematic roles that leads to the change in the meaning of the verb.

IV. CONCLUSION

The main results show that most of the sample verbs show a change in their meanings due to a change in their thematic roles as well as their selectional restrictions. This means that the majority of the thematic roles candidates proved that they affect the meaning of the verb. As such, they should be considered for verb sense disambiguation in MT systems.

The following flowchart shows a simple representation of the logical steps the MT system would follow for the purpose of word sense disambiguation.

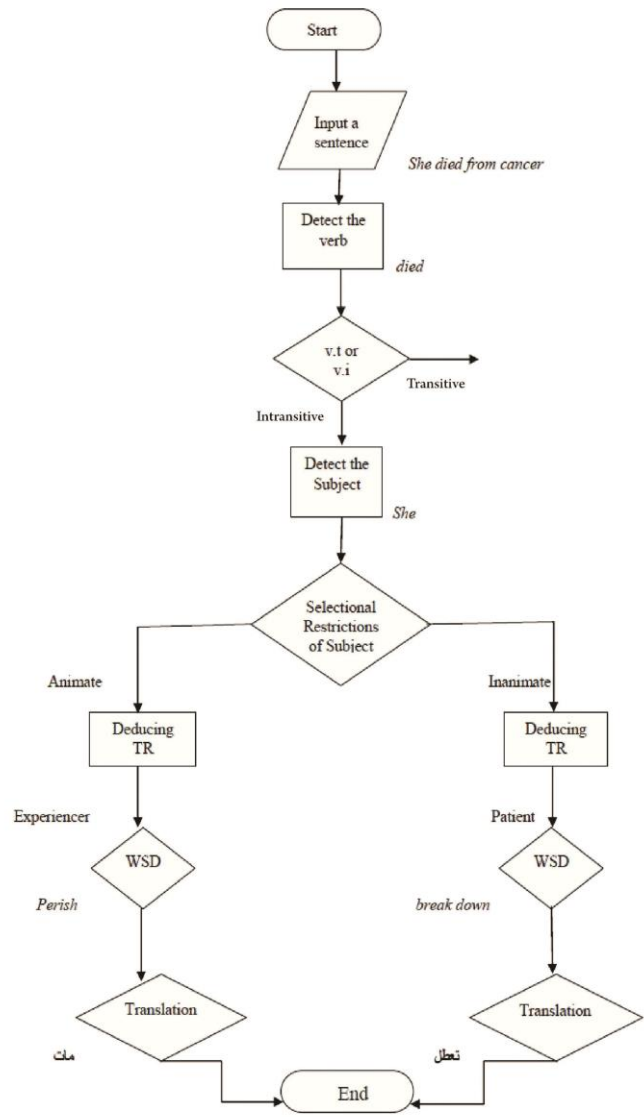


Figure 1: WSD Flow Chart. This figure illustrates the process of WSD and Translation of a verb.

First, the sentence is entered for translation, e.g. *She died from cancer*. The first process to be made is detecting the verb of the sentence: *died*. Reviewing the knowledge base, a choice has to be made as for whether the verb is transitive or intransitive. Some verbs have both forms. In such cases the machine has to detect whether there is an object (transitive) or not (intransitive). In the given example, ‘*died*’ is an intransitive verb. If the verb is intransitive, then the machine has to identify the subject only (*she*). The following decision is to review what selectional restriction is imposed on this subject. If it is <Animate>, then it is Experiencer thematic role. If it is <Inanimate>, then it is Patient thematic role. In the example, *she* is animate and, hence, it is Experiencer. After that the decision of word sense disambiguation is made. Since the verb *die* assigns an <Animate> Experiencer for its Subject, it means *perish*. However, if it assigns an <Inanimate> Patient for its Subject, it means *break down*. The final process to be

made is translating the verb. The verb *die* in the sense of *perish* is translated into the Arabic verb 'مات'.

V. RECOMMENDATION

The focus of this thesis is the verb. It examines how the meaning of the verb is affected by the change of the thematic roles and selectional restrictions assigned by the verb. It would be useful to examine whether thematic roles assigned by a given verb affect the meaning of the other nominal arguments not only the predicate of the sentence.

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