

A Cross-Lingual Grammar Model and its Application to Japanese-Spanish Machine Translation

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Abstract: This paper presents a grammar model for machine translation focused on the generation of the translated sentence. We base our model on the grammatical information of Spanish fragments, mainly focusing on parts of speech, in order to find out the information that is not contained in Japanese sentences but it's necessary to get a correct and more natural translation. We have tried some free online translators who claim to translate directly from Japanese to Spanish and have found out that they actually use a third language (English) as mediator or they lack accuracy. Using our model, we have created a Machine Translation Prototype System called JEMS. Based in the Kakari-Uke structure, at the moment of the transfer we know what the missing information is and add it to the translated sentence. Although our model is new and lacks vocabulary, we prove that, when applied, it gets better results than other translation systems.

クロスリンガル文法モデルとその日西翻訳への応用

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あらまし。日西機械翻訳システムには英語を介して翻訳するものが多い。それにより、不正確で不自然なスペイン語訳文が生成されることが多い。本論文では日本語からスペイン語へ英語を介さず直接翻訳する文法モデルと実験システムについて述べる。モデルはスペイン語の品詞にはあるが日本語の品詞にない文法的な情報に基づいて作成される。翻訳ルールの作成の上、プロトタイプの翻訳システムを作成して、「JEMS」と名付けた。JEMSは解析が「係り受け構造」に従って解析を進め、トランスファーが行われる前に、欠けている文法的な情報を認識し、訳文を生成するときに補完する。JEMSと他の直接に日本語からスペイン語へ翻訳出来ると言うオンラインソフトウェアとを比較した。その翻訳システムは精度があまり高くない、若しくは第三外国語（主に英語）を介して翻訳を行っていることが分かった。我々の現在のJEMSの単語数が少ないが、他の翻訳システムより翻訳品質が良く、又、訳文がもっと自然的であることを確認した。

1 Introduction

The relations between Japan and Mexico have become better and stronger in the last years. Thanks to free trade agreements and to the boom of the Japanese Pop Culture, now more people have access to the greatness of Japan. But there is a main problem that prevents people to know more detailed information about the mysticism of the Japanese Culture, and also that makes the agreements and business take more time: The Japanese language.

Being a language completely different to Spanish, it is not strange that, for native Spanish speakers, to learn Japanese is a very difficult task. Starting from the writing system composed by *Hiragana*, *Katakana* and *Kanji*, and continuing with the grammar, Spanish speakers quickly give up trying to learn it. Some of them manage to speak it at some level, but when it comes to read, specially Kanji, the number of people who can actually perform the task is incredibly reduced. For this reason, the first solution that comes to the mind of many of them is to use a translation system. That is our starting point.

Japanese-Spanish translation systems do exist, but their number is very small and, unfortunately, their accuracy is actually not so high. The main reason is because the translation is not performed directly from Japanese to Spanish, but first from Japanese to English and then from English to Spanish, thus, losing or missing some elements that may or may not exist in one of the languages. This kind of translation system may give the user a very general idea of what the original sentence wants to communicate, but it will miss for sure specific elements that are the key to understand the real meaning of the sentence. Moreover, sometimes they will show a word in pure English, meaning that they could not analyze it.

In this paper we summarize the analysis of the Japanese language from the point of view of Spanish. However, our research is more focused on the generation of the translated sentences. This means to have in mind all the elements that exist in Spanish when analyzing Japanese sentences. We also mention some of the problems that can be dealt with when translating from Japanese to Spanish and identify patterns and how to handle them. In order to get a better translation, we create translation rules to be applied at the moment of the generation. Last, we create a small Machine Translation Prototype System called JEMS to test those rules and patterns and compare the results with another Machine Translation System that also can translate directly from Japanese to Spanish. At our laboratory, we have been developing a series of Machine Translation Systems named CLINT[9]. They include Japanese-Thai, Japanese-Malay and Japanese-Chinese. The system we present in this paper is also included in it.

2 Spanish grammatical considerations in translation rules

As mentioned before, our research is mainly focus in the generation of the translated sentence. Thus, the creation of a *transfer dictionary* is needed in order to raise the accuracy of the translation. Figure 1 shows the model we propose (shown with straight arrows):

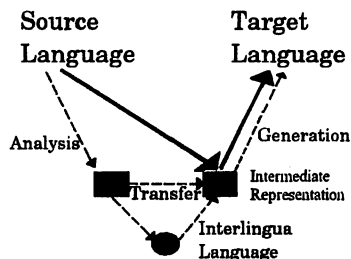


Figure 1: Translation Model focused on target language properties

In order for the transfer to be performed properly, we need the information of the Spanish parts of speech and also to know how to identify certain patterns in Japanese sentences and their proper handle when translating to Spanish. In this section we will cover the parts of speech, but due to the limited space, we won't explain them deeply.

2.1 Nouns

2.1.1 Gender and number

Noun's gender and number determine almost all the possible changes the other elements in a sentence can suffer. For this reason, they are a very important part of speech, because all other elements within a sentence must match main noun's properties.

Although it's true that there are rules to try to determine a noun's gender, the truth is there are many exceptions, that's why we need to have this information beforehand.

2.1.2 Categories

In this research, we use NTT ALT J/E Semantic Categorization [12] to get nouns categories, and we base our translation rules on them. At NTT Basic Research Laboratories, two experimental Machine Translation Systems from/to Japanese to/from English, named LUTE[8][7], were developed around the beginning of 1980's. In this study, they investigated a variety of linguistic features, by which they could realize the development of a series of LUTE systems. Following this basic research, NTT Applied Research Laboratories started to develop two practical systems: ALT J/E and ALT E/J.

and we got the same result when translating with Babel Fish Translator (<http://babel.altavista.com>) from *English to Spanish*.

- Temporary State.
- Permanent Feature.
- Weather.

Categories are not exclusive, but adjectives who fall in the “*Weather*” category generally don’t belong to any other. Also, even that categories exist, there are cases we still have to analyze the type of sentence in which an Adjective is used in order to select the correct verb.

Figure 2: ALT J/E Semantic Categorization Structure

2.1.3 Nouns that express time

These nouns are classified as 「時相名詞」 (tense nouns), and whenever we find one, we must treat it as an adverb unless it is the modified noun in an embedded sentence. Tense nouns, as its name implies, can determine the tense of the verb.

2.2 Adjectives

In Japanese, there are 2 kinds of adjectives: 「形容詞」 (i-adjective) and 「形容動詞」 (na-adjectives), and they are some of the parts of speech that can become the predicate of a Japanese sentence. However, when translating to Spanish, they become one single category.

As explained in section 2.1.1, adjectives have forms that change in order to match the noun they modify. We also have to have another consideration when they are the predicate of a sentence¹.

Basically, we use 2 verbs for this purpose: "*Ser*" and "*Estar*". Both are the equivalent to "To be" verb in English, but the main difference between them is that "*Ser*" indicates existence, whereas "*Estar*" expresses a situation, and action or a result. For instance, the sentence 「私は幸せだ」 (I am happy) can be translated as "*Soy feliz*" (using "*Ser*" verb) or "*Estoy feliz*" (using "*Estar*" verb), depending on what the subject wants to express.

Although this is a basic problem, some translation systems don't consider it at all. Worldlingo[5], for instance, translates 「彼女は悲しい」 as “*Ella es triste*”,

¹We identify 2 kinds of sentences in Spanish: Those with a subject-predicate structure and those without it. In this case, we focus on the former category

2.6 Translation Rules

A translation rule will contain:

- The verb to which it will be applied to.
- A series of particles than can appear in sentences in which the verb is used.
- The correct word (prepositions in most of the cases) to use in Spanish when translating particles (sometimes no word is needed).
- The category or categories to which the nouns that appear along with the particles must belong to in order for the rule to be applied.
- The Spanish translation for the verb in that case.
- An indication to know if the verb should be treated as Reflexive Verb.

A simple example could be the translation of the verb 「挙げる」. Without translation rules, the structure “Noun” + “Particle” + 挙げる is not enough when translating, because sentences like 「手を挙げる」 (raise a hand), 「例を挙げる」 (give an example) and 「結婚式を挙げる」 (celebrate a wedding) would all fall in that category. We need to be more specific, first, by using noun categories, and then, if necessary, specific nouns. For this example, we can create 3 simple rules as the ones shown in table 1. When in a sentence where the verb appears the conditions of a translation rule are fulfilled, we apply that rule to get the correct word to be used instead of the particle and also to get the correct translation of the verb for that particular case.

Verb	Part.	Word	Cat.	Trans.
挙げる	を	None	手	<i>Levantar</i>
挙げる	を	None	例	<i>Dar</i>
挙げる	を	None	結婚式	<i>Celebrar</i>

Table 1: Some simple examples of translation rules

When we say “Noun category”, it does not necessarily mean that the noun must belong exactly to that category. As ALT-J/E Semantic Categorization is in a tree structure (figure 2), categories are *parents* of the categories below them, unless of course we find a leaf node. Thus, if we find a rule where, for example, the expected noun category is 「場所」, and the noun that appeared in the sentence is 「学校」, even though the category of it is 「公共施設」 we can apply that rule because it is a descendant of 「場所」.

Translation rules will also be used sometimes to know if the noun should not use any articles, as in 「肉を食べる」, sentence that, without any context, is translated as “*Comer carne*”. This feature is still experimental, because in order to make a more accurate decision we need to have more contextual information.

Due to the space limitation, we don’t list further details about the proposed model. We resume it in figure 3:

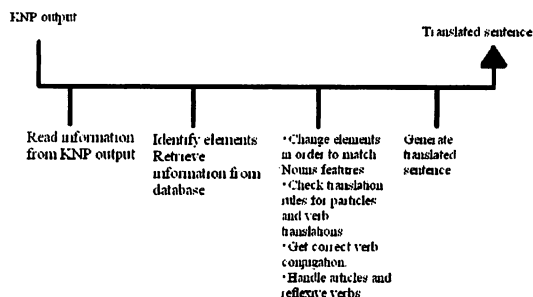


Figure 3: Translation Model

3 Voices

In this section, we discuss about passive voice and causative voice in Spanish: The patterns to identify and the measures to be taken when translating from Japanese.

3.1 Passive Voice

We identify Japanese passive voice by looking for the auxiliary verbs 「れる」, 「られる」, and the performer of the action is indicated by the 「に」 particles (although it is not present in all passive sentences). When translating to Spanish, there are 3 possible structures we can use.

3.1.1 Normal Passive Voice

Passive voice in Spanish resembles English passive voice. It is formed with the verb “Ser” (explained in section 2.2) and the participle of the verb, and the performer of the action is indicated with the preposition “por”.

For instance: 「ボールは子供に蹴られた」 (The ball was kicked by the child), or in Spanish, “*La pelota fue pateada por el niño*”. As expected, we find a difference in the Spanish sentence: The verb is 「蹴る」, in Spanish “*patear*”, and the participle for this verb is “*pateado*”, but participle is also affected by the gender of the noun that modifies, and thus we have to make the change to its female form, getting as result “*pateada*”.

3.1.2 Passive with Indirect Object reference

Gramatically speaking, passive voice in Spanish is defined as explained in the previous section. Sometimes, however, another sentence structure can be used to

express the same idea, and some other times that structure is the only one that can be used.

For instance, the sentence 「私は財布を盗まれた」, translated to English as “My wallet was stolen”, can be translated to Spanish either as “*Mi cartera fue robada*” (following the explanation in the previous section) or as “*Me robaron la cartera*”. Both are correct, but the latter is much more used. The difference is that the subject of the sentence is neither “I” (as could be implied by the Japanese sentence) nor “wallet” (as in the English translation), but “they”. “They” does not mean that we know who stole the wallet. It is just a way to understand that whenever that conjugation appears in these kind of sentences it indicates that the subject is unknown. However, we do know who received the action, in this case “I”, but the Spanish translation for it, “*Yo*” does not appear in the sentence and is not because it is omitted (it can not be omitted because, analyzing the verb, what is omitted is “they”). It is because “I” becomes the “*Indirect Object*”², and thus, *Indirect Object pronouns* must be used. Table 2 lists them:

Subject	Indirect Object Pronoun
I	<i>Me</i>
You	<i>Te</i>
He, she, it	<i>Le</i>
We	<i>Nos</i>
You (plural), they	<i>Les</i>

Table 2: Spanish Indirect Object Pronouns

Translating this kind of sentences requires essentially to change them to active voice, with the performer of the action as subject, the subject of the original sentence as the Indirect Object (with the addition of the correct Indirect Object Pronoun), and the correct conjugation of the verb. Thus 私は財布を盗まれた becomes (ZERO) は私に財布を盗んだ, where (ZERO) indicates the part of the sentence that is missing³. If we substitute (ZERO) with “They”, we know what conjugation we must look for. Just we have to be careful not to translate the pronoun, because if we do, it implies that we know who stole the wallet.

Even if the performer of the action was written in the sentence, like 「私は彼に財布を盗まれた」, it is more natural to say “*Él me robó la cartera*” (changing it to active voice) instead of using the real passive voice “*Mi cartera fue robada por él*”. Moreover, as mentioned at the beginning of this section, there are some sentences where only this structure can be used when translating to Spanish. Let’s analyze another

example: 「ここに3時に来てと言われた」.

In English, the previous sentence is translated as “*I was told to come here at 3:00*”, which falls in the first category analyzed. However, the only possible Spanish translation for this sentence is “*Me dijeron que viniera aquí a las 3:00*”, that is, the category we are just explaining. As a native speaker, I have to say I’ve never used nor heard something like “*Fui dicho que viniera a las 3:00*” (obtained following the steps for translating passive voice to Spanish). Thus ここに3時に来てと言われた becomes (ZERO) は私にここに3時に来てと言った.

3.1.3 Passive-Reflexive

The use of reflexive verbs when translating Japanese sentences that use passive voice needs a deep explanation.

Let’s take the sentence 「ここではパンが売られている」 (Bread is sold here). If we use what have been explained so far to translate to Spanish, we get “*Aquí venden pan*”, where the verb 「売る」 (vender) is conjugated using “They”. This sentence is grammatically correct and we can leave it the way it is. But, if the sentence is written in a sign, it’s more common to find it as “*Aquí se vende pan*”, because it emphasizes the action without caring who performs it.

Analyzing the sentence, we find the reflexive pronoun “*se*”, but it does not indicate that, because the verb becomes reflexive, the action returns to the subject, because “bread” can not sell itself. The verb becomes reflexive to indicate that what is important is that bread can be bought there. Also, the verb must be conjugated in singular-third person (“He, she, it”) to match the use of “*se*”

So far, only sentences with the pattern 「一では/には...一される」 and multiple sentences where there is no subject and performer of the action specified in the main sentence (with verbs like 「思う」 (to think), 「言う」 (to say), 「考える」 (to think), among others) have been identified to fall in this category. Some examples are:

- 日本では日本語は話される
- ここでは幽霊が見えると言われている
- 彼が殺人だと思われる
- あの事件は自殺だと考えられた

3.2 Causative Sentences

Causative Sentences in Japanese are identified easily because of the presence of the auxiliary verbs 「せる」, 「させる」. As well as in English, in Spanish we find 2 kind of sentences that correspond to causative sentences in Japanese, and each of them uses a different auxiliary verb:

²Indirect Object is a concept that does not exist in Japanese. A good explanation about it can be found at <http://spanish.allinfo-about.com/grammar/pronouns/pn-indirectobject.html>

³This feature is known as “*Pronoun Zero*”, or 「ゼロ代名詞」, and it’s the object of many researches

- **Coercitive Sentences:** As it names implies, in this kind of sentences the subject forces someone to do something against his or her will, as in 「彼女は子供を学校に行かせる」 (she forces the child to go to the school/she makes the child go to the school). The auxiliary verb used in this sentences is either “forzar”, “obligar” or “hacer”. The difference is that the elements needed to translate the causative sentence is different depending on which verb is used:

- If the auxiliary verb selected is either “forzar” or “obligar”, who is forced to perform the action must have the preposition “a” before it and the auxiliary verb unless it is a pronoun (see below), and before the translation of the verb there also must be an “a”.
- If the auxiliary verb selected is “hacer”, who is forced to perform the action must have the conjunction “que” before it if the verb takes subjunctive mood or “a” if the verb takes infinitive mood (see below), unless it is a pronoun (see below).

- **Permissive Sentences:** Instead of forcing, the subject allows someone do something, as in 「彼女は子供に学校へ行かせる」 (She lets the child go to the school). The auxiliary verb used in this sentences is always “Dejar”, and who is permitted to perform the action must be preceded by the conjunction “que” unless it is a pronoun (see below).

No matter what auxiliary verb was selected, in the case where who is forced or permitted to perform the action is a pronoun, instead of the translation of it, “Direct Object Pronouns” must be used. They are listed in table 3. In those cases, that pronoun is added before the auxiliary verb if the verb is not in imperative form, or at the end of the auxiliary verb if it is in imperative form.

Subject	Direct Object Pronoun
I	Me
You	Te
He, it	Lo
She	La
We	Nos
You (plural), they	Los
They (only women)	Las

Table 3: Spanish Direct Object Pronouns

Also, the tense of the auxiliary verb is decided by the verb in the Japanese sentence.

Before listing some examples, we have to mention that there is one more element that may change its form: The main verb. It can appear in infinitive form

or in *Subjunctive Mood*⁴. In the former, there’s nothing to be added, but if the latter is selected, then we have to add “que” before the verb and also it must be conjugated to match the person who is forced or permitted to perform the action and the tense of the auxiliary verb.

Following all the explanations given above, in order to translate them to Spanish, we must a special case for intransitive verbs and another for transitive verbs:

3.2.1 Case 1: Intransitive Verbs

The difference between the coercive and the permissive sentence is that who is forced to perform an action is, in the former, indicated with 「を」, whereas in the latter it is indicated with 「に」. Thus, taking the previous examples, we identify the sentence 「彼女は子供を学校に行かせる」 as coercive, and 「彼女は子供に学校へ行かせる」 as permissive, analyzing the presence of the particles 「を」 and 「に」.

Analyzing the first sentence, 「彼女は子供を学校に行かせる」, we find that 「子供」 (“el niño”) is the element who is being forced to go to the school. As it is not a pronoun, there is no need to use Direct Object Pronouns. Next, we must select an auxiliary verb. Let’s pick up “obligar”. This verb needs that the translation of 「子供」 has the preposition “a” before it, so we get “al niño”⁵. Next, we select the form the main verb will take. In this example we choose to write it in infinitive form, getting “ir”, and we add the preposition “a” before it, getting “a ir”. Last, we conjugate the auxiliary verb according to the subject of the sentence (「彼女」) and also get the translation for the subject. The final result is the translated sentence “Ella obliga al niño a ir a la escuela”. Should we had selected “hacer” instead of “obligar”, the final result would have been “Ella hace ir al niño a la escuela”. If we had chosen the verb to take subjunctive mood, then the results would have been “Ella obliga al niño a que vaya a la escuela” and “Ella hace que el niño vaya a la escuela” respectively.

As for the second sentence, the same rules apply, only the verb is different. The results are “Ella deja ir al niño a la escuela” and “Ella deja que el niño vaya a la escuela” respectively.

3.2.2 Case 2: Transitive Verbs

As transitive verbs can take an object, the only way to differentiate between coercive and permissive sentences is either analyzing the context of the sentence or looking for elements like 「無理に」, 「無理矢理に」, 「強引に」 (all of them translated as “by force”) or auxiliary verbs like 「やる」, 「あげる」, 「差し上げ

⁴Due to the limited space, we won’t explain Subjunctive Mood in this paper.

⁵When the prepositions “a” or “de” appear before the article “el”, it is common to contract them to “al” and “del” respectively.

る」、「くれる」、「下さる」 etc. (verbs that indicate to whom the action was performed for) in it. As for the auxiliary verbs and the forms the main verb can take, the rules are the same as for intransitive verbs.

Let's analyze an example: 「彼は彼女に酒を無理に飲ませた」. We look for expressions that help us decide whether the sentence is coercitive or not, and we find 「無理に」, so, this sentence is coercitive. Next, we identify 「彼女」 as the person being forced to perform the action, and as it is a pronoun, we use the proper Direct Object Pronoun: 「la». Adding it before the auxiliary verb, conjugating it properly and adding the translation of the subject, we get the expression 「Él la forzó». Now, the main verb. In infinitive form we just have to add 「a」 before it, getting 「a beber». In subjunctive mood, we have to add 「a que」 before the verb and also we have to conjugate it properly. In this case, the subject is 「he」 and the tense must be subjunctive preterite, because it has to match with the preterite of the auxiliary verb. Last, the translation of the object: 「vino」 (「酒」 refers to any alcoholic drink. In Spanish, 「vino」 (wine) is used the same way. Of course, 「酒」 can be translated also as 「sake»). The results are, for the first choice 「Él la forzó a beber vino», and for the second choice 「Él la forzó a que bebiere vino」.

3.3 Causative Passive Sentences

These sentences have, as its name indicates, both causative and passive auxiliary verbs. The patterns to look for are 「せられる」 and 「させられる」.

In order to translate these sentences, we just apply the rules for passive voice and causative sentences (using the rules for coercitive sentences) at the same time. Just one thing must be noted: It is more common to apply the rules for "Passive-Reflexive Sentences" rather than for "Normal Passive Voice". Thus, the sentence 「私は彼女に野菜を食べさせられる」 is more commonly translated as 「Ella me forzó a que comiera verduras」 instead of 「Fui obligado por ella a comer verduras», although, as explained before, both are grammatically correct.

4 System

The prototype system we developed is called JEMS, standing for *Japanese-Español⁶ Machine translation System*. We use JUMAN (<http://nlp.kuee.kyoto-u.ac.jp/nl-resource/juman.html>) and KNP (<http://nlp.kuee.kyoto-u.ac.jp/nl-resource/knp.html>) at the moment to perform the morphological and dependence analysis of Japanese sentences respectively.

We base our analysis in an algorithm (shown in Figure 4) that understands both the relationships between the elements thanks to the 「*KakariUke Analysis*」 and the structure of Spanish sentences. The user

just types the sentence in Japanese and the system presents the translated sentence, with the option of speak it in correct Spanish thanks to the use of *Microsoft Agent* (<http://www.microsoft.com/msagent>).

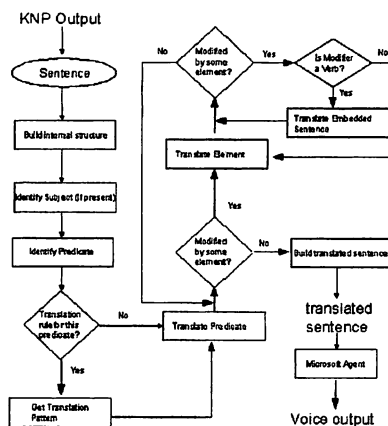


Figure 4: Flow Diagram for JEMS

4.1 Tests and Results

We tried our system against *Worldlingo*[5], another Machine Translation System that has the option to translate directly from Japanese to Spanish. We tested around 117 different sentences due to the lack of vocabulary we suffer because we are creating the data by ourselves. Of course there are some Japanese-Spanish vocabulary list, but their translation is not correct all the times and they lack the information we need to have in order to translate correctly. The sentences were taken from books for kids like "Momotaro", "San nen Netaro", "Shippo no tsumi", "Kaze no kami to kodomo", among others, slightly modified (we removed words that are used only in certain areas of Japan). The test consisted in human-translating the Japanese sentences to Spanish, and then, inputting those sentences into JEMS and Worldlingo and comparing the results against the human-translation. Results can be seen in fig 4:

Evaluation	JEMS	WL
Correct	58%	24%
Structure errors	18%	26 %
Conjugation errors	12%	11%
Incorrect	6%	25%
Other errors	6%	0%

Table 4: Test Results

The evaluation is divided into 4 categories:

- **Correct:** The translation sentence is as it was expected.

⁶ "Español" is the Spanish for "Spanish"

- **Structure errors:** The translation sentence is correct except for minor grammatical mistakes. The meaning can be still taken.
- **Conjugation errors:** The translation sentence is correct, but the verb conjugation is not correct. The meaning can be still taken.
- **Incorrect:** The translation is not correct. The grammatical structure is not correct. The meaning can not be guessed.
- **Other errors:** Errors caused because KNP Analysis was not as expected or was not correctly read.

Although the number of rules and patterns we tested is certainly not so big, we have proven that our structures, their information and the translation rules created, we just need to increase the vocabulary in our dictionary and create rules for more complicated structures in order to get better translations directly from Japanese to Spanish.

5 Concluding Remarks

In this paper we presented some grammatical considerations that must be taken in Japanese-Spanish Machine Translation. We showed examples, grammatical rules and how to deal with them. However, and due to the lack of space, we didn't mention anything about *Subjunctive Mood*, which is a very important subject when translating from a language that doesn't have it to a language where it is commonly used.

One of the main problems we are suffering now and will suffer for a long time is the lack of a vocabulary list. This causes the number of experiments we can run everytime is not as high as in papers about Japanese-English Machine Translation techniques.

Still, this is only the beginning. We have to create more rules and considerations, specially focused on longer sentences. Our goal is to get an accurate Spanish translation from a Japanese Text, and we think we have made the first step to accomplish it. And, also, we believe this research can open the doors to researches of Machine Translation to some other Romance Languages, like Portuguese or Italian, because they share many features with Spanish.

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