A study on machine translation of resultative constructions

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Abstract: Based on an empirical investigation on data collected from four popular machine translation systems, this paper explores the current problems machine translation is confronted with in translating Chinese resultative constructions into English. The paper analyzes their syntactic and semantic differences in construction and in verbal pattern. The paper then further elaborates on the problems and reveals a truth that Chinese resultative construction poses a great challenge to machine translation for being very productive and flexible. Its productivity is credited to the fact that the main verbs in Chinese are mostly implied-fulfillment verbs. Its flexibility could be attributed to the hypothesis that there are fewer constraints on the co-occurrence of the main verb and the resultative in Chinese resultative construction. Finally, possible solutions are proposed in an attempt to solve the problems.

Keywords: resultative construction; machine translation; implied-fulfillment verb

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1. Introduction

The term 'resultative' was first coined by Halliday (1967: 62–66) to distinguish two types of attributes, namely the resultative and the depictive. The corresponding Chinese term was first adopted by Lv (1980) to distinguish two types of complements, one indicating a result and the other a direction. Just as Thepkanjana and Uehara (2009) put it, there is indeed no single cross-linguistically accepted definition of the term 'resultative'; it can be semantically defined in a broad way as a term referring to linguistic forms that express a state and a previous event. The resultative state may be linguistically realized by many types of linguistic forms across languages. For instance, in Mandarin Chinese resultative constructions consist of a main verb and an adjective or a verb indicating a result (Lv, 1980: 11), which are also known in the literature as V-V compounds (Y. Li, 1990; Zou, 1994; Chang, 1997; etc.), resultative verb compounds (Thompson, 1973; Ross, 1990; C. Li, 2007, 2013; etc.), or verb-resultative constructions (Xia and Li, 2016; etc.). Unlike English resultative constructions, the main verb and the resultative predicate of a Chinese resultative construction are syntactically stuck together, allowing no elements between them. Chinese

resultative constructions are characteristic and known as a concise structure with rich meaning (L. Li, 1986: 198), which are pervasive in Chinese. In essence, their syntactic functions are not substantially different from those of a single verb, yet their semantics is much more complicated than the latter. In a word, Chinese resultative constructions have simple syntactic structures but complicated semantic relations, which hence poses a great challenge to machine translation.

Machine translation has come a long way in the past half century since the first public demonstration of its feasibility, a collaboration by IBM and Georgetown University, in 1954. With the introduction of corpora, rule-based machine translation has been developed into statistical machine translation. The latter takes advantage of the language model trained on monolingual data in the target language and there is no need to write rules manually. By directly training parallel corpora, a machine translation system can be built, which becomes the core technology of many online machine translation systems developed by companies such as Google, Baidu and the rest. But there still exist some problems in statistical machine translation, for it still relies on human experts for designing features to represent all kinds of translation knowledge. The advent of artificial intelligence fosters the development of deep learning and neural network, in which case companies such as Google and Baidu have successively developed neural machine translation systems based on big data, giving rise to superior translation accuracy. Although the current neural machine translation systems have achieved good results in daily conversation, news and other fields, machine translation is far from mature (Feng, 2018). Chinese resultative constructions are too difficult for machine translation to handle owing to their unique syntactic and semantic characteristics.

The rest of the article is organized as follows: Section 2 of this article will examine the problems machine translation is confronted with in translating Chinese resultative constructions into English based on a certain amount of data. In Section 3, a contrast between Chinese and English resultative constructions will be made. In Section 4, the previous problems will be accounted for in linguistic terms; what's more, possible solutions to these problems will be proposed. Section 5 concludes the article.

2. Data collection and discrepancies revealed in machine translation

This article selects about 200 common Chinese resultative constructions and collects all their English translations generated through four machine translation systems, namely Youdao, Baidu, Mr. Translator of Tencent (hereafter referred to as Tencent) and Google, and makes a preliminary statistical analysis of these data. According to the current data, the first three translation systems are probably based on similar parallel corpora, for they present similar or even the same translations for many Chinese resultative constructions while Google provides quite different translations. As far as the collected data are concerned, Google translation gets the lowest accuracy of the four translation systems with just around 16%, 11% lowering than the average.

A close examination and analysis of the available data shows that there exist many problems in the machine translation of Chinese resultative constructions into English, which can be roughly summarized as follows:

1) Only the result of the resultative construction is translated while the main verb is omitted, hence some semantic information is lost. For instance:

(1) *wo zou   lei   le*

    I   walk tired PERF

    'I became tired as a result of walking (e.g. a long distance/for a long time).'

The translation of (1) presented by Google is "*I am tired*", without any semantic information of the verb "*walk*". The other three give the same translation, "*I'm tired of walking*", the meaning of which is totally different from that of the original sentence.

Take another instance for example:

(2) *ta chi pang le*

    he eat fat PERF

    'He has put on some weight as a result of eating (too much).'

The translations given by the four translation systems are as follows:

(3) a. He put on weight. (Tencent)

    b. He has put on weight. (Youdao)

    c. He is fat. (Google)

    d. He's overweight. (Baidu)

Likewise, the translations fail to convey the semantic information of the main verb or the action verb.

The above-mentioned examples of Chinese resultative constructions are intransitive. The problem also occurs when it comes to some transitive resultative constructions, for example:

(4) *wo ting dong   le   zhe ju hua*

    I listen understand PERF this CL sentence

    'I listened to this sentence and understood it.'

All the four versions are almost the same except for their different tenses, "*I understand/ understood this sentence,*" in which only the resultative predicate is translated. The machine translation systems fail to distinguish between (4) and (5) by giving the exact same translations, without conveying the semantic meaning of the main verbs.

(5) *wo du dong   le   zhe ju hua*

    I read understand PERF this CL sentence

    'I read this sentence and understand it.'

It is widely believed in the literature that the action verb of a Chinese resultative construction is the syntactic head of the sentence while the resultative predicate is its semantic head. Thus, it is somehow reasonable to focus more on the meaning of the resultative predicate than the action

predicate, yet there is a semantic loss when the latter is totally omitted or ignored in translation.

2) The resultative meaning and the change of state are not translated accurately, hence there is a semantic discrepancy between the translated sentence and the original one. For example:

(6) *feng gua meng le*

   wind blow hard PERF

   'The wind is blowing harder (than before).'

Sentence (6) actually means that the gentle wind is now blowing more strongly than before and becomes fierce. It indicates the change of the scale of wind. However, the two different translations given by the four machine translation systems, "*The wind is blowing hard*" and "*The wind blew hard*", fail to accurately convey the change of state as well as the resultative meaning. This subtle difference between the translation and the original Chinese sentence is a big challenge to machine translation, which is also difficult for foreign language learners to grasp. The above translations are fine for another sentence, "*feng gua de meng* (wind blow fiercely)".

3) When it comes to cases where an instrument serves as the object of a resultative construction, all the four translation systems fail to present accurate translations. For instance:

(7) *wo ca zang le   liang kuai ma-bu*

   I wipe dirty PERF two pieces rag

   'I wiped something with two rags and as a result the two rags became dirty.'

The translations produced by the four translation systems are as follows:

(8) a. I wiped two rags. (Tencent)

   b. I soiled two rags. (Youdao)

   c. I rubbed two rags. (Google)

   d. I rubbed two rags dirty. (Baidu)

Sentence (7) aims to emphasize the change of state of the two rags instead of the object wiped by the agent '*I*'. The two rags undergo the change of state from being clean to being dirty as a result of the activity of the agent's wiping something. Yet the translations are far from being accurate and felicitous.

4) Some sentence patterns with Chinese resultative constructions are quite difficult for machine translation. Take the following as an example:

(9) *sheng-chan dui bing si   le   yi tou niu*

   production team sick die PERF one CL cow

   'A cow of the production team died of illness.'

The translations of this sentence given by the translation systems are as follows:

(10) a. The production team died of a cow. (Tencent; Google; Baidu)

　　b. The production team died of illness. (Youdao)

This sentence pattern of resultative construction is unique to Chinese and is very special, hence extremely demanding for machine to translate. Some existing studies regard this pattern as inverted resultative construction, arguing that it is the object of the sentence that is the experiencer of the causative predicate and the resultative predicate. The subject of the sentence pattern ranges from a patient of the main verb to a location. In (9), the subject of the sentence is actually the owner of the object while the object '*niu* (cow)' is the experiencer of the verbs '*bing* (fall ill) and '*si* (die)'. The two versions indicate that it is impossible for machine to felicitously process this kind of sentence.

Another example:

(11) *cun　　li　　bing　si　　le　　yi　ge　ren*

　　village inside fall ill die PERF one CL man

　　'In the village a man died of illness.'

Surprisingly, the translation systems do a much better job concerning (11). Tencent and Youdao give the same translation "*A man died of illness in the village*" while a similar translation is given by Baidu "*One man died of illness in the village*". However, the one produced by Google is not as good as the previous ones, "*A person died in the village.*" Obviously, Google only presents the result, missing the semantic information of the main verb, or rather the cause of the result.

Some complex sentences with resultative constructions are also very challenging for machine translation to deal with. For example:

(12) *ta ping-pang ji ba-zhang　jiu　　ba hai-zi da ku　le*

　　he bang-bang a few palm at once OBJ child beat cry PERF

　　'As soon as he gave the child a few slaps the child cried (because of being beaten).'

The following translations presented by the translation systems are far from good.

(13) a. He slapped the child with a few slaps. (Tencent)

　　b. He slapped the child at the table tennis and it began to cry. (Youdao)

　　c. He slapped a few pats and cries his child. (Google)

　　d. He gave the child a few slaps at table tennis and cried. (Baidu)

Tencent fails to present the result. Both Youdao and Baidu identify '*ping-pang*' as '*table tennis*', a noun instead of an onomatopoetic word, which is hereby a simulation of the sound produced by beating somebody with one's palm. Thus, both (13b) and (13d) are misinterpretations of (12). The translation given by Google is unreadable and unacceptable.

When it comes to patient subjective sentences with resultative constructions, whose subject is not the agent of the verb, the accuracy of machine translation is also low. For instance:

(14) *jian-bang tai zhong   le*

shoulder lift swollen PERF

'The shoulder(s) became swollen as a result of carrying (something heavy).'

The translations are only focused on the resultative predicate without any information of the causative predicate. There is no reflection of the semantic relation between the causative predicate and the resultative predicate in the translations, as illustrated in (15).

(15) a. My shoulders are swollen. (Tencent)

b. The shoulder is swollen. (Youdao)

c. The shoulders are swollen. (Google)

d. The shoulders were swollen. (Baidu)

5) In some Chinese resultative constructions, the resultative predicates are virtually evaluative rather than resultative. Some scholars argue that evaluation is also one type of result. In the existing literature, those structures are widely regarded as resultative constructions. Typologically speaking, it is more economical to classify them into the category of resultative construction, yet some studies point out their particularities and label them as atypical resultative constructions. They are different from typical ones especially in that the secondary predicate is an adjective serving as a certain evaluation. It can be some evaluation on the subject or the action. Take (16) for example:

(16) *quan'er hua   xiao   le*

circle   draw small PERF

'The circle has been drawn, yet it is too small.'

The translations given by machine are as follows:

(17) a. The circle is small. (Tencent; Google)

b. The circles are getting smaller. (Youdao)

c. The circle is smaller. (Baidu)

All the above translations fail to present the semantic meaning of the action verb. Nor do they reflect the evaluation. The original sentence means that the drawn circle is too small, not big enough, or smaller than expected or required.

Another instance:

(18) *xiao li   lai   zao   le*

Xiao Li come early PERF

'Xiao Li came too early.'

Google and Baidu translate (18) into "*Xiao Li came early*" while the other two present the translation as "*Xiao Li is early*". The former translation is better than the latter, for the semantic

meaning of the action verb '*lai* (come)' is given. However, it only conveys that Xiao Li came early rather than Xiao Li coming too early (than necessary). The evaluative meaning of the resultative is lost in the translation.

Another example:

(19) *zhe shi'er ni you   ban   chi le*

this matter you again handle/deal with late PERF

'Again you are too late for dealing with this matter.'

(20) a. You're late for this again. (Tencent; Youdao; Baidu)

b. You're too late to do this. (Google)

(20a) focuses on the resultative without mentioning the action verb. There is no reflection of evaluation indicated in the original sentence. Google gives a better translation as in (20b).

To sum up, Chinese resultative constructions have brought many difficulties to machine translation due to their unique syntactic and semantic characteristics. There are still quite a few problems even for the big-data-based neural machine translation to solve.

3. Differences between Chinese and English resultative constructions

In order to solve the problems machine translation encounters, it is not enough to base on the current parallel corpora. It is necessary to build a supplementary and specialized corpus of Chinese resultative constructions so that it is feasible to carry out more effectively and accurately machine translation of Chinese resultative constructions into any other language, say, English. For most Chinese resultative constructions, there are no equivalent English resultative constructions available. Chinese resultative constructions differ greatly from those in English both syntactically and semantically.

3.1. Types of resultative construction in Chinese and English

Based on the previous studies (Guo, 1995; Wang, 1996; Song, 2007; Shi, 2008; etc.), Chinese resultative constructions can be roughly classified into the following types:

(21) a. *zhang san da shang le   li si*

Zhang San beat injured PERF Li Si

'Zhang San beat Li Si and as a result Li Si was injured.'

b. *zhang san ku shi le   shou-pa*

Zhang San cry wet PERF handkerchief

'Zhang San cried and (his tears) wetted his handkerchief.'

c. *zhang san han ya le sang-zi*

Zhang San shout hoarse PERF throat

'Zhang San shouted himself hoarse.'

d. *zhang san zou   lei   le*

Zhang San walk tired PERF

'Zhang San got tired because of walking (too much).'

e. *zhang san   qi   si   le   li si*

Zhang San irritate die PERF Li Si

'Zhang San irritated Li Si so much so that Li Si died (from anger).'

f. *ping-guo chi huai   le   du-zi*

apple   eat wrong PERF stomach

'I ate the apple and it spoiled my stomach.'

g. *zhe jian shi   qi   si   le   li si*

this CL matter irritate die PERF Li Si

'This matter irritated Li Si so much so that Li Si died.'

(21a)–(21d) are the four basic forms of resultative constructions in Chinese. In (21a), the action verb is a transitive verb and its patient serves as the object of the sentence, which is also the experiencer of the resultative predicate. Thus, the object of the construction has a semantic relation with both the action verb and the resultative. In (21b), the action verb is intransitive, hence the object of the construction only has a semantic relation with the resultative predicate, being the agent argument of the resultative. In (21c), the action verb is transitive, yet what serves as the object of the resultative construction is not its direct argument or patient argument, but one of its obliques, which functions as the agent argument of the resultative predicate. In (21d), both the action verb and the resultative predicate are intransitive (most adjectives in Chinese may fall into verbs). The agent argument of the resultative construction is also the agent argument of both the action verb and the resultative. The resultative of the construction is subject-oriented, and that is why the resultative construction can no longer take an object.

(21e)–(21g) are three types of causative resultative construction classified according to source of the causer. In (21e), the agent of the main verb serves as the causer. In (21f), the patient of the action verb serves as the causer and hence becomes the subject of the resultative construction. In (21g), some other independent component rather than the agent or patient of the action verb serves as the causer and hence the subject of the resultative construction.

In addition to the above types, there are some resultative constructions which are classified as atypical ones by some researchers, such as:

(22) a. *wan-fan chi zao le*

dinner eat early PERF

'It was too early for having the dinner.'

  b. *gou wa qian   le*

ditch dig shallow PERF

'The ditch dug is too shallow.'

The resultative adjective in (22a) is a comment on the activity, or rather the time when the event took place while the one in (22b) is on the depth of the ditch that has been dug. Whether these constructions fall into the (21f) or they are just variants of that type remains controversial.

Beavers (2012: 908) defines English resultative constructions as those clauses in which, in addition to the main verb (V), there is an additional, secondary predicate (the result XP), predicating some state that comes about for some participant in the event as a result of the action described by the clause. In general, result XPs are Adjective Phrases (APs) or Prepositional Phrases (PPs); Determiner Phrases (DPs) are not common; but XPs cannot be Verb Phrases (VPs). Various types of resultatives are hereby outlined.

(23) a. OBJECT-ORIENTED TRANSITIVE ACTIVE

    i. John hammered the metal flat.

    ii. John swept the floor clean.

  b. BARE XP

    i. The lake froze solid.

    ii. The vase broke open.

  c. UNERGATIVE + FAKE REFLEXIVE/NON-SUBCATEGORIZED OBJECT

    i. We searched the woods and cliffs, yelled ourselves hoarse and imagined you drowned …

    ii. The jogger ran his Nikes threadbare.

  d. OBJECT DROP + NON-SUBCATEGORIZED OBJECT

    i. The bankers drank the pub dry.

    ii. Sudsy cooked them all into a premature death with her wild food.

  e. SUBJECT-ORIENTED TRANSITIVE ACTIVE

    i. The wise men followed the star out of Bethlehem.

    ii. John swam laps to exhaustion.

Resultatives of (23a) are the most oft-cited resultatives which have transitive Vs, with the XP predicating of the object. In (23b), resultatives occur with intransitives that take a single patient

argument; the matrix subject is the subject of the XP and there is no object. In (23c), unergatives generally only take XPs if a fake reflexive or a non-subcategorized object is added and the objects are obligatory. In (23d), non-categorized objects take place of the default objects of some transitive verbs. In (23e), although the verbs are transitive the XPs skip the objects to predicate of the subjects. (Beavers, 2012: 909–914)

Machine translation does a much better job when translating English resultative constructions into Chinese. Most resultative constructions of type (23a) and type (23b) can be translated into corresponding Chinese resultative constructions while a lot of resultative constructions of type (23c) can also be matched with Chinese resultative constructions. When it comes to type (23d), it is hard to translate resultatives of this type into Chinese counterparts. English resultative constructions of (23ei) indicate change-of-location instead of change-of-state, which do not fall into resultative construction in Chinese. Although there might be no equivalent Chinese resultative construction for each English resultative construction, the accuracy of translation turns out to be much higher than that of machine translation of Chinese resultative constructions into English.

3.2. Semantic differences in the main verb of resultative construction

In addition to the syntactic differences between Chinese resultative constructions and English ones, another key issue is the main verb in the construction. Talmy (2000: 261–263) postulates four verbal patterns, exhibiting varying degrees of realization of the Agent's intention. Each type can enter construction with a different type of semantically complementary satellite: 1) intrinsic-fulfillment verbs co-occur with a further event satellite; 2) moot-fulfillment verbs co-occur with a fulfillment satellite; 3) implied-fulfillment verbs co-occur with a confirmation satellite; and 4) attained-fulfillment verbs tend to disfavor even a semantically pleonastic satellite.

Thepkanjana and Uehara (2009) argue that "the result of the causing action, rather than the agent's intention, is a semantic property which is intrinsic in the semantics of the causing verb and that the degree of its intrinsicness varies from verb to verb." Leaving aside the realization of an agent's intention as claimed by Talmy, this article also focuses on the semantics of verb.

English is not rich in implied-fulfillment verbs and has only scattered examples, yet this verbal pattern is a major type in Mandarin Chinese. Talmy (2000: 272) points out that "Mandarin is a strongly satellite-framed language, regularly using its satellites to specify path, aspect, state change, some action correlation, and much realization." In other words, Chinese is rich in implied-fulfillment verbs which require a satellite for their realization. That's why resultative constructions are very common and frequently used in Chinese. Resultative predicates are required for confirmation or realization, indicating a change of state caused by a previous event and making the action telic and bounded.

On the other hand, Chinese resultative constructions are more productive than English ones, since their main verbs are mostly implied-fulfillment verbs. Teng (1972) points out the difference between the English verb *kill* and the corresponding verb '*sha*' in Mandarin Chinese. The former consists of a causing action and a resulting state while the latter has only the causing action although it may imply the resulting state of death. Tai and Chou (1975) present further evidence and arguments and claim that English verbs, such as *kill*, *find*, and *learn*, imply an attainment of a certain goal, which must be expressed by means of verb compounds in Chinese, generally resultative constructions,

namely '*sha si*', '*zhao dao*', '*xue hui*' respectively. They also claim that "they have so far found no Chinese action verbs which imply the attainment of goal." There are almost no attained-fulfillment verbs in Chinese while English is rich in this verbal pattern. Attained-fulfillment verbs tend to disfavor even a semantically pleonastic satellite. For instance, the English verb *drown* does not allow the addition of *dead* or *to death*, as in *I drowned him *dead/ *to death* (Talmy, 2000: 267). Thus, attained-fulfillment verbs in English do not occur in resultative constructions.

It is noted that implied-fulfillment verbs are a major type of the main verb in Chinese resultative constructions, requiring the co-occurrence of a resultative predicate for confirmation. As Talmy (2000: 266) puts it, the meaning of the confirmation satellite is not independent of the verb's meaning, but is sensitive to its internal semantic structure and complements the structure. Yet what implied by the verb might turn out to have many possibilities. Take the verb '*za* (pound)' for example. The verb means 'pound; tamp; thump against something using a heavy thing; (of a heavy object) drop on another object'. It implies that the affected object might be damaged, yet the resulting state must be confirmed by a resultative predicate. The verb can be followed by different resultative predicates, such as '*si* (die)', '*shang* (injure)', '*yun* (dizzy/faint)', '*hui* (be destroyed)', '*sui* (be in pieces)', '*lan* (broken)', '*huai* (destroyed/break)', '*duan* (break)', '*po* (broken/damaged)', '*bian* (flat)'. It is argued that Chinese resultative constructions are very productive since a single verb may form quite a few constructions with different resultatives while a resultative can be the result of various actions and hence form different constructions with different action verbs. However, there are some constraints on the co-occurrence of the main verb and the resultative predicate of a typical Chinese resultative construction. First, there is a causative relation between the verb and the result. Second, the causative relation between them is reasonable and convincing according to world knowledge.

4. An account of the previous problems and proposed solutions

The problems machine translation encounters in translating Chinese resultative constructions into English can be attributed to the syntactic and semantic differences between Chinese resultative constructions and English resultative constructions, especially the special syntactic and semantic relations of resultative constructions in Chinese.

4.1. An account of the problems

As Talmy (2000: 268) mentions, "The implicature associated with the implied-fulfillment type of verb apparently behaves not as a discrete factor that is either present or absent, but as on a cline with different degrees of strength." Talmy takes *choke-stab-strangle-drown* as a set of examples. The verb *choke* has no or has a slight implicature of killing while the verb *drown* is determinate and clearly precludes denial. There is an increasing degree of implicature of fulfillment across the four example verbs. Unlike English verbs, the implicature associated with the implied-fulfillment type of verb in Chinese is fuzzy in itself and the strength of force varies from resultative construction to resultative construction depending on the resultative the verb co-occurs with. The verb '*za* (pound)', for example, can co-occur with a variety of resultatives. When the affected object is an animate being, the effect or harm caused by the action might vary in degree, such as '*yun* (dizzy/faint)', '*shang* (injure)' or '*si* (die)'. Thus, the strength of force is confirmed and determined by the resultative predicate. The resultative constructions formed by the action verb co-occurring with

different resultative predicates form a cline. When the affected object is something, say, an artifact, the damage caused by the action verb might be '*bian* (flat)', '*huai* (destroyed/broke)', '*sui* (be in pieces)', '*hui* (be destroyed)', etc. Most of the resultative predicates co-occurring with the verb '*za*' are verbs. Indeed, two events are involved in each resultative construction: the causing event and the resulting event.

Two resultative constructions occur in the following example:

(24) *you tong   bu-dan za   shang le   ta-de tui,*

oil barrel/drum not only pound injured PERF her   leg,

hai   za   bian le   ta-de san-lun-che

but also pound flat PERF her   tricycle

a. The barrel not only hurt her leg, but also crushed her tricycle. (Youdao)

b. The oil bucket not only hurt her leg, but also flattened her tricycle. (Baidu; Tencent)

c. The oil drum not only injured her leg, but also squashed her tricycle. (Google)

The main verb of the Chinese sentence gives a very specific description of how her leg was injured and how her tricycle became flat, yet the above translations do not give equivalent semantic information of the first half of the sentence. The translations of the second half are much better, since both the meaning of the main verb and that of the resultative of this Chinese resultative construction are somehow implied in the English verbs *crush* and *squash*, although there are still subtle differences between them. According to Collins dictionary, if someone or something is squashed, they are pressed or crushed with such force that make them injured or lose their shape. The English verb *squash* may co-occur with a confirmation satellite or a resultative, as in (25). The verb *flatten* in (24b) seems less good, for it mainly focuses on the resultative.

(25) … and boot, the youth noted with interest, had been squashed flat as a potato pancake. (Corpus of Contemporary American English)

Although English is relatively rich in attained-fulfillment verbs, they do not really correspond in meaning with Chinese resultative constructions. It is necessary that machine translation systems should be designed to identify the causing event and the resulting event.

Take another Chinese verb for example, '*da* (beat/strike)'. '*da po* (break)', '*da sui* (break into pieces)', '*da si* (beat die)', '*da shang* (beat injured)', '*da yun* (beat faint)', '*da duan* (beat break)', '*da ku* (beat cry)', just to name a few. '*da* (beat/strike)' may fall into the verbal pattern of intrinsic-fulfillment verb termed by Talmy. "With this verbal pattern, the addition of a satellite adds a semantic increment that is wholly extrinsic to the referential content of the verb." (Talmy, 2000: 263) In '*da ku* (beat cry)', '*ku* (cry)' adds some meaning to the verb, thus the act of beating is understood to cause a further event, crying. When someone is beaten, they might be knocked out, or injured, or even die. The English verb *stun* is an attainment-fulfillment verb, making someone unconscious is attained as in *The blow he got on the head stunned him*. But in Chinese a further-event satellite is generally added to express a result caused by the act, that is, the resultative predicate in the construction. For a verb of this pattern, the resultative adds an additional meaning

which is wholly extrinsic to the verb. There is usually a causative relation between the main verb and the resultative, or the further event is caused by a previous one. It is noted that '*da po* (break)' is widely believed to be lexicalized in many cases, where it functions more like a compound verb, for '*da* (beat) and '*po* (break/broken)' are unlikely to be taken as two separate events, especially in the cases involving abstract nouns such as in '*da po chang-gui* (break the routine)', '*da po jiang-ju* (break the deadlock)', '*da po ji-lu* (break the record)'.

The reasons why Chinese resultative constructions are so difficult for machine translation to process are that they are very productive and flexible and that there are much fewer constraints on the co-occurrence of the main verb with the resultative in contrast to English.

As Talmy (2000: 275) points out, "Mandarin conative verbs can enter into construction not only with satellites expressing fulfillment or confirmation, but also with ones that express 'underfulfillment', 'over-fulfillment', 'antifulfillment', and 'other-event'." For example, the verb '*zhe*' is an implied-fulfillment verb with the implicature that something, especially a linear object, gets broken. Thus, the verb can take a resultative to confirm the implicature, as in '*zhe she/duan* (break broken/snapped)'. However, it can also take another resultative '*wan* (bent)', indicating a bent state rather than a broken state. Such a resultative is an underfulfillment satellite in Talmy's term. Meanwhile, the verb '*wan* (bend)' with the implicature of getting bent can also take what Talmy calls an overfulfillment satellite, such as '*she* (broken)', which marks an access. (Talmy, 2000: 275–276)

Chinese also allows a verb to take a resultative that indicates the reverse of the implied result by the verb. In (26), the implied-fulfillment verb '*xi* (wash)' means 'immerse and agitate with the goal of cleansing thereby', yet it can also take the resultative '*zang* (dirty)', a reverse of the implied result '*gan-jing* (clean)'. A resultative for this semantic effect on the verb falls into what Talmy terms as antifulfillment satellite.

(26) *wo ba chen-yi xi   zang le*

    I OBJ shirt wash dirty PERF

    'I washed the shirt dirty.'

    "I washed the shirt (e.g., in the river), but it came out dirtier than before."

(Talmy, 2000: 276)

In addition, a resultative in Chinese can also express a state that results from the action verb but that does not lie on the conceptual axis leading to the verb's represented goal. For example, the verb '*xi* (wash)' could take a resultative '*po*' with the meaning 'torn', as illustrated in (27). This sentence means that the agent performed the action with the implied meaning of getting it clean, but this action unexpectedly led to the shirt's becoming torn. In Talmy's term such a resultative is an other-event satellite.

(27) *wo xi   po le   chen-yi*

    I wash torn PERF shirt

    'I washed the shirt torn.'

"I washed the shirt, and it got torn in the process."

(Talmy, 2000: 277)

It is noted that the problems machine translation encounters could be boiled down to the semantic relation between the verb and the resultative. For most cases, there is a causative relation between the action and the result. Even when the change of state does not fall along the conceptual axis leading to what implied by the action verb, it still is a state caused by the action.

4.2. Solutions proposed

The first thing is that the machine translation systems should be able to identify the causing event and the result event based on the main verb and the resultative predicate. When there is a sufficiently conceptual and causative relation between two events, it is possible to combine the two events into a complex one and to create a novel resultative construction thereby. For example, Haisong Jiang, who studied in the United States, slipped through the security barrier at Newark Airport to kiss his girlfriend goodbye when he saw her off at the airport. His trespass led to the six-hour shutdown of one of the airport's terminals, grounding more than 100 flights and forcing thousands of passengers to go through security again. "A goodbye kiss of a Chinese overseas student paralyzed an American airport" became the headline in Chinese newspapers in the US, as illustrated in (28).

(28) *zhong-guo liu-xue-sheng   yi   ge wen   bie,*

China   overseas student one CL kiss goodbye

wen tan   le   yi   ge mei-guo ji-chang

kiss paralyzed PERF one CL America airport

'A goodbye kiss of a Chinese overseas student paralyzed an American airport.'

(29) a. Chinese students kiss goodbye and crash at an American airport. (Youdao)

b. Chinese students kiss goodbye and paralyze an American airport. (Baidu; Tencent)

c. A Chinese student kissed goodbye, and the kiss paralyzed an American airport. (Google)

Although "*wen tan* (kiss paralyze)' is a very novel and occasional resultative construction, it is very vivid and makes good sense. For machine translation, only when it can identify the two events and their causative relation, can it do a pretty good job, as shown by Google in (29c).

However, the processing of machine translation is quite unsatisfactory when it comes to resultative constructions such as "*kan sha*", the main verb with the meaning 'look' while the resultative predicate with the most common meaning 'silly', yet in (30) and (31) the resultative does not mean 'silly', but 'dumbfounded'.

(30) *na   bang   ren kan   sha   le*

that group people look dumbfounded PERF

'That group of people became dumbfounded when they looked (at something amazing).'

(31) *na fu hua'er ba ta kan   sha   le*

     that CL picture OBJ him look dumbfounded PERF

     'That picture left him dumbfounded when he looked at it.'

The translations given by the systems for the above two sentences are as follows:

(32) a. Those people look stupid. (Tencent)

     b. Those people look silly. (Youdao)

     c. The guys are stupid. (Google)

     d. Those guys look silly. (Baidu)

(33) a. The picture made a fool of him. (Tencent)

     b. That painting made a fool of him. (Youdao)

     c. The picture made him look silly. (Google)

     d. The picture made him look foolish. (Baidu)

None of the translations can accurately translate the meaning of the original Chinese sentence, with the failure of identifying the two events and their causative relation. The event expressed by the main verb is that somebody looks at something and the result event is that they become 'silly'. Identifying the two events is still not enough to produce a right and good translation, especially when the word has more than one meaning. When the semantic relation between the two events turns out to be unreasonable according to encyclopedic knowledge, other meanings should be taken into consideration. For (30) and (31), another meaning of the resultative '*sha*', which can be glossed as 'dumbfounded', could render the semantic relation more reasonable. In order to achieve this, a knowledge base is advisable.

To sum up, Chinese resultative constructions are highly productive and flexible. Moreover, there are a wide variety of possibilities of the co-occurrence between the main verb and the resultative when it comes to Chinese resultative construction. It is almost impossible to build a corpus to include all possible resultative constructions in Chinese. Thus, it is advisable to base on corpora as large as possible. In order to improve efficiency and accuracy of machine translation, it is feasible to add more related rules. Considering peculiarities of Chinese resultative construction, more specialized rules should be manually written and added to the current systems. Meanwhile a knowledge base would be a great helper in telling the semantic relation between the two events when it is against common senses or violates encyclopedic knowledge; the system could be able to make an adjustment and search for a better and more reasonable translation.

5. Conclusion

This paper explores and analyses the problems machine translation encounters in translating Chinese resultative constructions into English. Those problems could be linguistically attributed to syntactic differences in construction structure and semantic differences in verb pattern between

Chinese and English. Above all, Chinese resultative constructions are difficult for machine translation for being productive and flexible. On the one hand, resultative constructions are very productive in Chinese due to the abundance of implied-fulfillment verbs in Mandarin Chinese, which require a confirmation satellite for realization. Meanwhile, the resultatives add a confirmation meaning to the verb and make the event telic and bounded. On the other hand, Chinese resultative constructions are flexible since there are few constraints on the co-occurrence of the main verb and the resultative.

The paper proposes that there are several ways to improve efficiency and accuracy of machine translation of resultative constructions. First, a larger parallel corpus is advisably used to train machine translation systems. Second, more specialized rules should be manually written and added to the current systems. Third, a knowledge base could be built and serves as an assistant to identify and encode complex semantic relations. Machine translation of resultative constructions, especially that of Chinese ones, requires more further research.

Author contributions

Xiaoxia Pan is the only author and did all the work involved in this study.

Conflict of interest

No conflict of interest was reported by the author.

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