Bilingual Collocation Extraction Based on Syntactic and Statistical Analyses

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Abstract

In this paper, we describe an algorithm that employs syntactic and statistical analysis to extract bilingual collocations from a parallel corpus. The preferred syntactic patterns are obtained from idioms and collocations in a machine-readable dictionary. Phrases matching the patterns are extract from aligned sentences in a parallel corpus. Those phrases are subsequently matched up via cross-linguistic statistical association. Statistical association between the whole collocations as well as words in collocations is used jointly to link a collocation and its counterpart collocation in the other language. We experimented with an implementation of the proposed method on a very large Chinese-English parallel corpus with satisfactory results.

1. Introduction

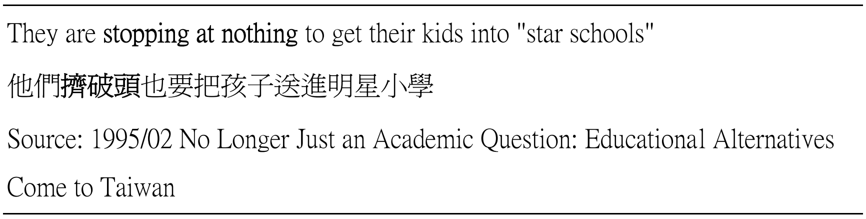
Collocations like terminology tend to be lexicalized and have a somewhat more restricted meaning than the surface form suggested (Justeson and Katz 1995). Collocations are recurrent combinations of words that co-occur more often than chance. The words in a collocation may appear next to each other (rigid collocations) or otherwise (flexible/elastic collocations). On the other hand, collocations can be classified into lexical and grammatical collocations (Benson, Benson, Ilson, 1986).

Lexical collocations are formed between content words, while the grammatical collocation has to do with a content word and function words or a syntactic structure. Collocations are pervasive in all types of writing and can be found in phrases, chunks, proper names, idioms, and terminology. Collocations in one language are usually difficult to translate directly into another language word by word, therefore present a challenge for machine translation systems and second language learners alike.

Automatic extraction of monolingual and bilingual collocations are important for many applications, including natural language generation, word sense disambiguation, machine translation, lexicography, and cross language information retrieval. Hank and Church (1990) pointed out the usefulness of mutual information for identifying monolingual collocations in lexicography. Justeson and Katz (1995) proposed to identify technical terminology based on preferred linguistic patterns and discourse property of repetition. Among many general methods presented by Manning and Schutze (1999), best results can be achieved by filtering based on both linguistic and statistical constraints. Smadja (1993) presented a method called EXTRACT, based on means variance of the distance between two collocates capable of computing elastic collocations. Kupiec (1993) proposed to extract bilingual noun phrases using statistical analysis of co-occurrence of phrases. Smadja, McKeown, and Hatzivassiloglou (1996) extended the EXTRACT approach to handling of bilingual collocation based mainly on the statistical measures of Dice coefficient. Dunning (1993) pointed out the weakness of mutual information and showed that log likelihood ratios are more effective in identifying monolingual collocations especially when the occurrence count is very low.

Both Smadja and Kupiec used the statistical association between the whole of collocations in two languages without looking into the constituent words. For a collocation and its paraphrasing translation counterpart, that is reasonable. For instance, with the bilingual collocation (“擠破頭”, “stop at nothing”) in Example 1, it is not going to help looking into the statistical association between “stopping” and “擠” [ji] (sqeeze) (or “破” [bo, broken] and “頭” [tou, head] for that matter). However, with the bilingual collocation (“減薪”, “pay cut”) in Example 2, considering the statistical association between “pay” and “薪” [xin] (wage) as well as “cut” and “減” [jian, reduce] certainly makes sense. Moreover, we have more data to make statistical inference between words than phrases. Therefore, measuring the statistical association of collocations based on constituent words will help to cope with the data sparseness problem. We will be able to extract bilingual collocations with high reliability even when they appear together in aligned sentences only once or twice.

Example 1

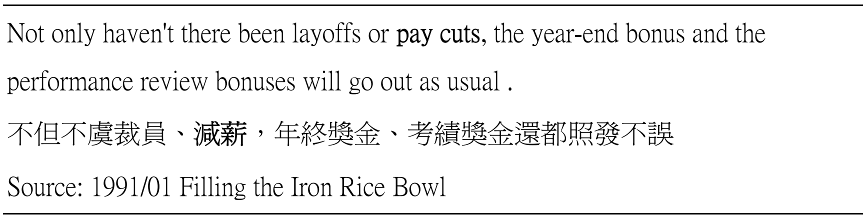


They are **stopping at nothing** to get their kids into "star schools"

他們**擠破頭**也要把孩子送進明星小學

Source: 1995/02 No Longer Just an Academic Question: Educational Alternatives Come to Taiwan

Example 2



Not only haven't there been layoffs or **pay cuts**, the year-end bonus and the performance review bonuses will go out as usual .

不但不虞裁員、**減薪**，年終獎金、考績獎金還都照發不誤

Source: 1991/01 Filling the Iron Rice Bowl

Since the collocations could be rigid or flexible in both languages, we can generally classify the match type of bilingual collocation into three types. In Example 1, (“擠破頭”, “stop at nothing”) is a pair of rigid collocations, and (“把…送

進”, “get … into”) is a pair of elastic collocations. In Example 3 ,(“走…的路線’, “take the path of”) gives the example for a pair of elastic and rigid collocations.

Example 3

Lin Ku-fang, a worker in ethnomusicology, worries too, but his way is not to take the path of revolutionizing Chinese music or making it more "symphonic"; rather, he goes directly into the tradition, looking into it for "good music" that has lasted undiminished for a hundred generations.

民族音樂工作者林谷芳也非不感到憂心，但他的方法是：不走國樂改革或「交響化」的路，而是直接面對傳統、從中尋找歷百代不衰的「好聽音樂」。

Source: 1997/05 A Contemporary Connoisseur of the Classical Age--Lin Ku-fang's Canon of Chinese Classical Music

In this paper, we describe an algorithm that employs syntactic and statistical analyses to extract rigid lexical bilingual collocations from a parallel corpus. Here, we focus on the bilingual collocations, which have some lexical correlation between them and are rigid in both languages. To cope with the data sparseness problem, we use the statistical association between two collocations as well as that between their constituent words. In Section 2, we describe how we obtain the preferred syntactic patterns from collocation and idioms in a machine-readable dictionary. Examples will be given to show how collocations matching the patterns are extracted and aligned for a given aligned sentence pairs in a parallel corpus. We experimented with an implementation of the proposed method for the Chinese-English parallel corpus of Sinorama Magazine with satisfactory results. We describe the experiments and evaluation in Section 3. The limitations and related issues will be taken up in Section 4. We conclude and give future directions in Section 5.

2. Extraction of Bilingual Collocations

In this chapter, we will describe how we obtain the bilingual collocation by using the preferred syntactic patterns and associative information. Consider a pair of aligned sentences in a parallel corpus such as Example 4 given below:

Example 4

The civil service rice bowl, about which people always said "you can't get filled up, but you won't starve to death either," is getting a new look with the economic downturn. Not only haven't there been layoffs or pay cuts, the year-end bonus and the performance review bonuses will go out as usual, drawing people to compete for their own "iron rice bowl."

以往一向被認爲「吃不飽、餓不死」的公家飯，值此經濟景氣低迷之際，不但不虞裁員、減薪，年終獎金、考績獎金還都照發不誤，因而促使不少人回頭競逐這隻「鐵飯碗」。

Source: 1991/01 Filling the Iron Rice Bowl

We are supposed to extract the following collocations and translation counterparts:

(civil service rice bowl, 公家飯)
(get filled up, 吃…飽)
(starve to death, 餓…死)
(economic downturn, 經濟景氣低迷) (pay cuts, 減薪)
(year-end bonus, 年終獎金)
(performance review bonuses, 考績獎金)
(iron rice bowl, 鐵飯碗)

In Section 2.1, we will first show how that process is carried out for Example 4 under the proposed approach. The formal description will be given in Section 2.2.

2.1 An Example of Extracting Bilingual Collocations

To extract bilingual collocations, we first run part of speech tagger on both sentences. For instance, for Example 4, we get the results of tagging in Example 4A and 4B.

In the tagged English sentence, we identify phrases that follow a syntactic pattern from a set of training data of collocations. For instance, “jj nn” is one of the preferred syntactic structures. So, ”civil service,” “economic downturn,” and “own iron,”…etc are matched. See Table 1 for more details. For Example 4, the phrases in Example 4C and 4D are considered as potential candidates for collocations because they match at least two distinct collocations listed in LDOCE:

Example 4A

The/at civil/jj service/nn rice/nn bowl/nn ,/, about/in which/wdt people/nns always/rb said/vbd "/`` you/ppss can/md 't/* get/vb filled/vbn up/rp ,/, but/cc you/ppss will/md 't/* starve/vb to/in death/nn either/cc ,/rb "/" is/bez getting/vbg a/at new/jj look/nn with/in the/at economic/jj downturn/nn ./. Not/nn only/rb have/hv 't/* there/rb been/ben layoffs/nns or/cc pay/vb cuts/nns ,/, the/at year/nn -/in end/nn bonus/nn and/cc the/at performance/nn review/nn bonuses/nn will/md go/vb out/rp as/ql usual/jj ,/, drawing/vbg people/nns to/to compete/vb for/in their/pp$ own/jj "/`` iron/nn rice/nn bowl/nn ./. "/"

Example 4B

以往/Nd 一向/Dd 被/P02 認爲/VE2 「/PU 吃/VC 不/Dc 飽/VH 、/PU 餓不死/VR 」/PU 的/D5 公家/Nc 飯/Na ，/PU 值此/Ne 經濟/Na 景氣/Na 低迷/VH 之際/NG ，/PU 不但/Cb 不虞/VK 裁員/VC 、/PU 減薪/VB ，/PU 年終獎金/Na 、/PU 考績/Na 獎金/Na 還都/Db 照/VC 發/VD 不誤/VH ，/PU 因而/Cb 促使/VL 不少/Ne 人/Na 回頭/VA 競逐/VC 這/Ne 隻/Nf「/PU 鐵飯碗/Na 」/PU

Example 4C

“civil service,” ” rice bowl,” ” iron rice bow,” ” fill up,” ” economic downturn,” ” end bonus,” ” year - end bonus,” ” go ut,” ” performance review,” ” performance review bonus,” ” pay cut,” ” starve to death,” ” civil service rice,” ” service rice,” ” service rice bowl,” ” people always,” ” get fill,” ” people to compete,” ” layoff or pay,” ” new look,” ” draw people”

Example 4D

“吃不飽,” “餓不死,” “公家飯,” “經濟景氣,” “景氣低迷,” “經濟景氣低迷,” “裁員,” “減薪,” “年終獎金,” “考績獎金,” “競逐,” ” 鐵飯碗.”

Although “new look” and “draw people” are legitimate phrases, they more like “free combinations” than collocations. That reflects from their low log likelihood ratio values. For that, we proceed to see how tightly the two words in overlapping bigrams within a collocation associated with each other; we calculate the minimum of the log likelihood ratio values for all bigrams. With that, we filter out the candidates that its POS pattern appear only once or has minimal log likelihood ratio of less than 7.88. See Tables 1 and 2 for more details.

In the tagged Chinese sentence, we basically proceed the same way to identify the candidates of collocations and based on the preferred linguistic patterns of the Chinese translation of collocations in an English-Chinese MRD. However, since there is no space delimiter between words, it is at time difficult to say whether the translation is a multi-word collocation or it is a single word and should not be considered as a collocation. For that reason, we take multiword and singleton phrases (with two or more characters) into consideration. For instance, in the tagged Example 2C, we will extract and consider the following candidates as the counterparts of English collocations:

Notes that at this point, we are not pinned down on the collocations and allow overlapping and conflicting candidates such as “經濟景氣,” “景氣低迷,” “經濟景氣低迷.” See Tables 3 and 4 for more details.

Table 1 The initial candidates extracted based on preferred patterns trained on collocations listed in LDOCE.

E-collocation Candidate	Part of Speech	Pattern Count	Min LLR
civil service	jj nn	1562	496.156856

rice bowl	nn nn	1860	99.2231161
iron rice bowl	nn nn nn	8	66.3654678
filled up	vbn rp	84	55.2837871
economic downturn	jj nn	1562	51.8600979
*end bonus	nn nn	1860	15.9977283
year - end bonus	nn - nn nn	12	15.9977283
go out	vb rp	1790	14.6464925
performance review	nn nn	1860	13.5716459
performance review bonus	nn nn nn	8	13.5716459
pay cut	vb nn	313	8.53341082
starve to death	vb to nn	26	7.93262494
civil service rice	jj nn nn	19	7.88517791
*service rice	nn nn	1860	7.88517791
*service rice bowl	nn nn nn	8	7.88517791
* people always	nn rb	24	3.68739176
get filled	vb vbn	3	1.97585732
* people to compete	nn to vb	2	1.29927068
* layoff or pay	nn cc vb	14	0.93399125
* new look	jj nn	1562	0.63715518
* draw people	vbg nn	377	0.03947748

* indicates invalid candidate

Table 2 The candidates of English collocation based on both preferred linguistic patterns and log likelihood ratio

E-collocation Candidate	Part of Speech	Pattern Count	Min LLR
civil service	jj nn	1562	496.156856
rice bowl	nn nn	1860	99.2231161
iron rice bowl	nn nn nn	8	66.3654678
filled up	vbn rp	84	55.2837871
economic downturn	jj nn	1562	51.8600979
*end bonus	nn nn	1860	15.9977283
year - end bonus	nn - nn nn	12	15.9977283
go out	vb rp	1790	14.6464925
performance review	nn nn	1860	13.5716459
performance review bonus	nn nn nn	8	13.5716459
pay cut	vb nn	313	8.53341082
starve to death	vb to nn	26	7.93262494
civil service rice	jj nn nn	19	7.88517791
*service rice	nn nn	1860	7.88517791
*service rice bowl	nn nn nn	8	7.88517791

* indicates invalid candidate

Table 3 The initial candidates extracted by the Chinese collocation recognizer.

C-collocation Candidate	POS	Patter Count	Min LLR
不少 人	Ed Na	2	550.904793
*被 認爲	PP VE	6	246.823964
景氣 低迷	Na VH	97	79.8159904
經濟 景氣 低迷	Na Na VH	3	47.2912274
經濟 景氣	Na Na	429	47.2912274
公家 飯	Nc Na	63	42.6614685
*不 飽	Dc VH	24	37.3489687
考績 獎金	Na Na	429	36.8090448
不虞 裁員	VJ VA	3	17.568518
回頭 競逐	VA VC	26	14.7120606
*還都 照	Db VC	18	14.1291893
*發 不誤	VD VH	2	13.8418648
*低迷 之際	VH NG	10	11.9225789
*値此 經濟 景氣	VA Na Na	2	9.01342071
*値此 經濟	VA Na	94	9.01342071
*照 發	VC VD	2	6.12848087
*人 回頭	Na VA	27	1.89617179

* indicates invalid candidate

Table 4 The result of Chinese collocation candidates extracted which are picked out. (the ones which have no Min LLR are singleton phrases)

C-collocation Candidate	POS	Patter Count	Min LLR
不少 人	Ed Na	2	550.904793
*被 認爲	PP VE	6	246.823964
景氣 低迷	Na VH	97	79.8159904
經濟 景氣 低迷	Na Na VH	3	47.2912274
經濟 景氣	Na Na	429	47.2912274
公家 飯	Nc Na	63	42.6614685
*不 飽	Dc VH	24	37.3489687
考績 獎金	Na Na	429	36.8090448
不虞 裁員	VJ VA	3	17.568518
回頭 競逐	VA VC	26	14.7120606
*還都 照	Db VC	18	14.1291893
*發 不誤	VD VH	2	13.8418648
*低迷 之際	VH NG	10	11.9225789
*値此 經濟 景氣	VA Na Na	2	9.01342071
*値此 經濟	VA Na	94	9.01342071
之際	NG	5	

經濟	Na	1408	
景氣	Na	1408	
年終獎金	Na	1408	
考績	Na	1408	
獎金	Na	1408	
鐵飯碗	Na	1408	
公家	Nc	173	
以往	Nd	48	
值此	VA	529	
裁員	VA	529	
回頭	VA	529	
減薪	VB	78	
競逐	VC	1070	
認爲	VE	139	
低迷	VH	731	
不誤	VH	731	
不虞	VJ	205	
促使	VL	22	
餓不死	VR	14	

To align collocations in both languages, we follow the idea of Competitive Linking Algorithm proposed by Melamed (1996) for word alignment. Basically, the proposed algorithm **CLASS**, Collocation Linking Algorithm based on Syntax and Statistics, is a greedy method that selects collocation pairs. The pair with higher association value takes precedence over those with a lower value. CLASS also imposes a one-to-one constraint on the collocation pairs selected. Therefore, the algorithm at each step considers only pairs with words not selected before. However, CLASS differs with CLA in that it considers the association between the two candidate collocations in two aspects:

- Logarithmic Likelihood Ratio between the two collocations in question as a whole.
- Translation probability of collocation based on constituent words

For Example 4, the CLASS Algorithm first calculates the counts of collocation candidates in the English and Chinese part of the corpus. The collocations are matched up randomly across from English to Chinese. Subsequently, the co-occurrence counts of these candidates across from English to Chinese are also tallied. From the monolingual collocation candidate counts and cross language concurrence counts, we produce the LLR values and the collocation translation probability derived from word alignment analysis.. Those collocation pairs with zero translation probability are ignored. The lists are sorted in descending order of LLR values, and the pairs with low LLR value are discarded. Again, for Example 4, the greedy selection process of collocation starts with the first entry in the sorted list and proceeds as follows:

1. The first, third, and fourth pairs, ("iron rice bowl," "鐵飯碗"), ("year-end bonus," "年終獎金"), and ("economic downturn," "經濟景氣低迷"), are selected first. And that would exclude conflicting pairs from being considered including the second, fifth pairs and so on.
2. The second, fifth entries ("rice bowl," "鐵飯碗") and ("economic downturn," "値此經濟景氣") and so on, conflict with the second and third entries that are already selected. Therefore, CLASS skips over those.
3. The entries ("performance review bonus," "考績獎金"), ("civil service rice," "公家飯"), ("pay cuts," "減薪"), and ("starve to death," "餓不死") are selected next.
4. CLASS proceeds through the rest of the list and the other list without finding any entries that do not conflict with the seven entries selected previously.
5. The program terminates and output a list of seven collocations.

Table 5 The result of Chinese collocation candidates extracted which are picked out. The shaded collocation pairs are selected by the CLASS (Greedy Alignment Linking E).

English collocations	Chinese collocations	LLR	Collocation Translation Prob.
iron rice bowl	鐵飯碗	103.3	0.0202
rice bowl	鐵飯碗	77.74	0.0384
year-end bonus	年終獎金	59.21	0.0700
economic downturn	經濟 景氣 低迷	32.4	0.9359

economic downturn	値此 經濟 景氣	32.4	0.4359
...	. . .	...	...
performance review bonus	考績 獎金	30.32	0.1374
economic downturn	景氣 低迷	29.82	0.2500
civil service rice	公家 飯	29.08	0.0378
pay cuts	減薪	28.4	0.0585
year-end bonus	考績 獎金	27.35	0.2037
performance review	考績	27.32	0.0039
performance review bonus	年終獎金	26.31	0.0370
starve to death	餓不死	26.31	0.5670
...	. . .	...	...
rice bowl	公家 飯	24.98	0.0625
iron rice bowl	公家 飯	25.60	0.0416
…	…	…	…

2.2 The Method

In this section, we describe formally how CLASS works. We assume availability of a parallel corpus and a list of collocations in a bilingual MRD. The sentences and words have been aligned in the parallel corpus. We will describe how **CLASS** extracts bilingual collocations in the parallel corpus. CLASS carries out a number of preprocessing steps to calculate the following information:

1. Lists of preferred POS patterns of collocation in both languages.
2. Collocation candidates matching the preferred POS patterns.
3. N-gram statistics for both languages, N = 1, 2.
4. Log likelihood Ratio statistics for two consecutive words in both languages.
5. Log likelihood Ratio statistics for a pair of candidates of bilingual collocation across from one language to the other.
6. Content word alignment based on Competitive Linking Algorithm (Melamed 1997).

Figure 1 illustrates how the method works for each aligned sentence pair (*C*, *E*) in the corpus. Initially, part of speech taggers process *C* and *E*. After that, collocation candidates are extracted based on preferred POS patterns and statistical association between consecutive words in a collocation. The collocation candidates are subsequently matched up across from one language to the other. Those pairs are sorting according to log likelihood ratio and collocation translation probability. A greedy selection process goes through the sorted list and selects bilingual collocations subject to one to one constraint. The detailed algorithm is given below:

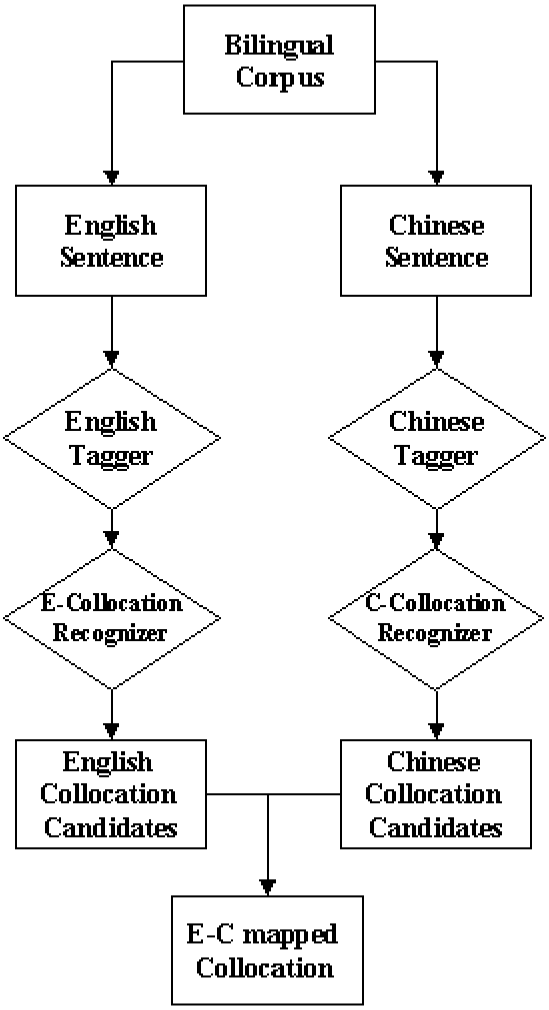


Figure 1 The major components in the proposed CLASS algorithm

Preprocessing: Extracting preferred POS patterns *P* and *Q* in both languages

Input: A list of bilingual collocations from a machine-readable dictionary

Output:

1. Perform part of speech tagging for both languages

2. Calculate the number of instances for all POS patterns in both languages
3. Eliminate the POS patterns with instance count 1.

Collocation Linking Alignment based on Syntax and Statistics

Extract bilingual collocations in aligned sentences.

Input:

(1) A pair of aligned sentences (C, E), C = (C_1 C_2 ... C_n) and E = (E_1 E_2 ... E_m)
(2) Preferred POS patterns P and Q in both languages

Output: Aligned bilingual collocations in (C, E)

1. C is segmented and tagged with part of speech information T.
2. E is tagged with part of speech sequences S.
3. Match T against P and S against Q to extract collocation candidates X_1, X_2,....X_k in English and Y_1, Y_2, ...,Y_e in Chinese.
4. Consider bilingual each collocation candidates (X_i , Y_j) in turn and calculate the minimal log likelihood ratio LLR between X_i and Y_j

   MLLR (D) = $\min_{i=1,n-1} LLR(W_i , W_{i+1})$
5. Eliminate candidates with LLR smaller than a threshold (7.88).
6. Match up all possible linking from English collocation candidates to Chinese ones: (D_1, F_1), (D_1, F_2), … (D_i, F_j), … (D_m, F_n).

Log-likelihood ratio: LLR(x;y)

$$LLR(x;y) = -2\log_2 \frac{p_1^{k_1}(1-p_1)^{n_1-k_1}\, p_2^{k_2}(1-p_2)^{n_2-k_2}}{p^{k_1}(1-p)^{n_1-k_1}\, p^{k_2}(1-p)^{n_2-k_2}}$$

k_1 : # of pairs that contain x and y simultaneously.
k_2 : # of pairs that contain x but do not contain y.
n_1 : # of pairs that contain y
n_2: # of pairs that does not contain y
p_1 = k_1/n_1, $p_2 = k_2/n_2$,
p = $(k_1+k_2)/(n_1+n_2)$

7. Calculate LLR for (D_i, F_j), and discard pairs with LLR value lower than 7.88.
8. The candidate list of bilingual collocations is considered only the one with non-zero collocation translation probability P(D_i, F_j) values. The list is then sorted by the LLR values and collocation translation probability.
9. Go down the list and select a bilingual collocation if it is not

Collocation translation probability P(x | y)

$$P(D_i \mid F_j) = \frac{1}{k}\sum_{e\in F_j} \max_{c\in D_i} P(c \mid e)$$

k : number of words in the English collocation F_j

conflicting with previous selection.

10. Output the bilingual collocation selected in Steps 10.

3. Experiments and Evaluation

We have experimented with an implementation of CLASS based on Longman dictionary of Contemporary English, English-Chinese Edition and the parallel corpus of Sinorama magazine. The articles from Sinorama cover a wide range of topics, reflecting the personalities, places, and events in Taiwan for the past three-decade. We experiment on articles mainly dated from 1995 to 2002. Sentence and word alignment were carried out first for Sinorama parallel Corpus.

Sentence alignment is a very important aspect of the CLASS. It is the basis of a good collocation alignment. We using a new alignment method based on punctuation statistics (Yeh & Chang, 2002). The punctuation-based approach outperforms the length-based approach with precision rates approaching 98%. With the sentence alignment approach, we obtain approximately 50,000 reliably aligned sentences containing 1,756,000 Chinese words (about 2,534,000 Chinese characters) and 2,420,000 English words in total.

The content words were aligned based on Competitive Linking Algorithm. Alignment of content words resulted in a probabilistic dictionary with 229,000 entries. We evaluated 100 random sentence samples with 926 linking types, and the precision is 93.3%. Most of the errors occurred with English words having no counterpart in the corresponding Chinese sentence. The translators do not always translate the word for word. For instance, with the word “water” in Example 4, it seems that these is no corresponding pattern in the Chinese sentence. Another major cause of errors is collocations that are not translated compositionally. For instance, the word “State” in the Example 6 is a part of the collocation “United States”, and “美國” is more highly associated with “United” than “States”, therefore due to one-to-one constraint “States” will not be aligned with “美國”. Most often, it will be aligned incorrectly. About 49% error links belongs to this kind.

Example 5

The boat is indeed a vessel from the mainland that illegally entered Taiwan waters. The words were a "mark" added by the Taiwan Garrison Command before sending it back.

編按：此船的確是大陸偷渡來台船隻，那八個字只不過是警總在遣返前給它加的「記號」！

Source: 1990/10 Letters to the Editor

Example 6

Figures issued by the American Immigration Bureau show that most Chinese immigrants had set off from Kwangtung and Hong Kong, which is why the majority of overseas Chinese in the United States to this day are of Cantonese origin.

由美國移民局發表的數字來看，中國移民以從廣東、香港出海者最多，故到現在爲止，美國華僑仍以原籍廣東者佔大多數。

Source: 1990/09 All Across the World: The Chinese Global Village

We obtained word-to-word translation probability from the result of word alignment. The translation probability P($c|e$) is given below:

$$\mathrm{P}(c|e) = \frac{count(e,c)}{count(e)}$$

count(e,c) : number of alignment linking between a Chinese word c and an English word e

count(e): number of instances of e in alignment likings.

Let's take "pay" as an example. Table 6 shows the various alignment translations for "pay" and the translation probability.

Table 6 The aligned translations for the English word "pay" and their translation probability

Translation	Count	Translation Prob.	Translation	Count	Translation Prob.
代價	34	0.1214	花錢	7	0.025
錢	31	0.1107	出錢	6	0.0214
費用	21	0.075	租	6	0.0214
付費	16	0.0571	發給	6	0.0214
領	16	0.0571	付出	5	0.0179
繳	16	0.0571	薪資	5	0.0179
支付	13	0.0464	付錢	4	0.0143
給	13	0.0464	加薪	4	0.0143
薪水	11	0.0393	. . .	...	...
負擔	9	0.0321	積欠	2	0.0071
費	9	0.0321	繳款	2	0.0071
給付	8	0.0286			

Before running CLASS, we obtained 10,290 English idioms, collocations, and phrases together with 14,945 Chinese translations in LDOCE. After part of speech tagging, we had 1,851 distinct English patterns, and 4326 Chinese patterns. To calculate the statistical association of within words in a monolingual collocation and across the bilingual collocations, we built N-grams for the SPC. There were 790,000 Chinese word bigram and 669,000 distinct English bigram. CLASS identified around 595,000 Chinese collocation candidates (184,000 distinct types), and 230,000 English collocation candidates (135,000 distinct types) in the process.

We selected 100 sentences to evaluate the performance. We focused on rigid lexical collocations. The average English sentence had 45.3 words, while the average Chinese sentence had 21.4 words. The two human judges both master student majoring in Foreign Languages identified the bilingual collocations in these sentences.

We then compared the bilingual collocations produced by CLASS against the answer keys. The evaluation indicates an average recall rate = 60.9 % and precision = 85.2 % (See Table 7).

Table 7 Experiment result of bilingual collocation extracted from Sinorama parallel Corpus

# keys	#answers	#hits	#errors	Recall	Precision
382	273	233	40	60.9%	85.2%

4. Discussions

This paper describes a new approach to automatic acquisition of bilingual collocations from a parallel corpus. Our method is an extension of Melamed's Competitive Linking Algorithm for word alignment, combining both linguistic and statistical information for recognition of monolingual and bilingual collocations in a much simpler way than Smadja's work. We differ from previous work in the following ways:

1. We use a data-driven approach to extract monolingual collocations.
2. Unlike Smadja and Kupiec, we do not commit to two sets of monolingual collocations. Instead, we consider many overlapping and conflicting candidate and rely on the cross linguistic statistics to revolve the issue.
3. We combine both information related to the whole collocation as well as those of constituent words for more reliable probabilistic estimation of aligned collocations.

The approach is limited by its reliance on the training data of mostly rigid collocation patterns and is not applicable to elastic collocations such as "jump on …

bandwagon.” For instance, the program cannot handle the elastic collocation in following example:

Example 7

台灣幸而趕**搭**了一程獲利豐厚的**順風車**，可以將目前剛要起步的馬來西亞、中國大陸等國家遠拋身後。

Taiwan has had the good fortune to **jump on** this high-profit **bandwagon** and has been able to snatch a substantial lead over countries like Malaysia and mainland China, which have just started in this industry.

(Source: Sinorama, 1996, Dec Issue Page 22, Stormy Waters for Taiwan’s ICs)

That limitation can be partially alleviated by matching nonconsecutive word sequence against existing lists of collocations for the two languages.

Another limitation has to do with bilingual collocations, which are not literal translations. For instance, “difficult and intractable” is not yet handled in the program, because it is not a word for word translation of “桀傲不馴”.

Example 8

意思是說一個再怎麼**桀傲不馴**的人，都會有人有辦法制服他。

This saying means that no matter how difficult and intractable a person may seem, there will always be someone else who can cut him down to size.

Source: 1990/05 A Fierce Horse Ridden by a Fierce Rider

In the experiment process, we found that the limitation may be partially solved by spliting the candidate list of bilingual collocations into two lists: one (NZ) with non-zero phrase translation probabilistic values and the other (ZE) with zero value. The two lists are then sorted by the LLR values. After extracting bilingual collocations from NZ list, we could continue to go downing the ZE list and select bilingual collocations if not conflicting with previously selection.

In the proposed method, we did no t take advantage of the correspondence of POS patterns from one language to the other. Some linking mistakes seem to be avoidable with the POS information. For example, the aligned collocation for "issue/**vb** visas/**nns**" is "簽證/**Na**", instead of "發/**VD** 簽證/**Na.**" However, the POS pattern "vb nn" appears to be more compatible with "VD Na" than "Na."

Example 9

一九七二年澳洲承認中共，中華民國即於此時與澳斷交。因爲無正式邦交，澳洲不能在台灣**發簽證**，而由澳洲駐香港的使館代辦，然後將簽證送回台灣，簽證手續約需五天至一周。

The Republic of China broke relations with Australia in 1972, after the country recognized the Chinese Communists, and because of the lack of formal diplomatic relations, Australia felt it could not **issue visas** on Taiwan. Instead, they were handled through its consulate in Hong Kong and then sent back to Taiwan, the entire process requiring five days to a week to complete.

Source: 1990/04 Visas for Australia to Be Processed in Just 24 Hours

A number of mistakes are caused with the erroneous word segments process of the Chinese tagger. For instance, "大學及研究生出國期間" should be segmented as " 大學 / 及 / 研究生 / 出國 / 期間" but instead segment was "大學 / 及 / 研究 / 生出 / 國 / 期間 / 的 / 學業." Another major source of segmentation mistakes has to do with proper names and their transliterations. These name entities that are not included in the database are usually segmented into single Chinese character. For instance, "...一書作者劉學銚指出..." is segmented as " ... / 一 / 書 / 作者 / 劉 / 學 / 銚 / 指出 / ...," while "...在匈牙利地區建國的馬札爾人..." is segmented as "...在 / 匈牙利 / 地區 / 建國 / 的 / 馬 / 札 / 爾 / 人 / ...." Therefore, handling these name entities in a pre-process should be helpful to avoid segment mistakes, and alignment difficulties.

5. Conclusion and Future Work

In this paper, we describe an algorithm that employs syntactic and statistical analyses to extract rigid bilingual collocations from a parallel corpus. Phrases matching the preferred patterns are extract from aligned sentences in a parallel corpus. Those phrases are subsequently matched up via cross-linguistic statistical association. Statistical association between the whole collocations as well as words in collocations is used jointly to link a collocation and its counterpart. We experimented with an implementation of the proposed method on a very large Chinese-English parallel corpus with satisfactory results.

A number of interesting future directions suggest themselves. First, it would be interesting to see how effectively we can extend the method to longer and elastic collocations and to grammatical collocations. Second, bilingual collocations that are proper names and transliterations may need additional considerations. Third, it will be interesting to see if the performance can re improved cross language correspondence between POS patterns.

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