Quality Classification and Evaluation of Human-Machine Composite Translations of Scientific Text Based on KPCA

Di Fan
School of Humanities and Foreign Languages
Xi'an University of Technology
Xi'an, China
e-mail: fandi@xaut.edu.cn

Ruizhe Chen
School of Humanities and Foreign Languages
Xi'an University of Post & Telecommunications
Xi'an, China
e-mail: chenruizhe@xupt.edu.cn

Jie Xue
School of Foreign Languages
Northwest University of Political Science and Law
Xi'an, China
e-mail: xuejie@nwupl.edu.cn

Yuchen Zhao
School of Automation and Information Engineering
Xi'an University of Technology
Xi'an, China
e-mail: zhaoyuchen@xaut.edu.cn

***Abstract*—In this paper, the kernel principal component analysis (KPCA) is applied to perform the translation quality classification and evaluation of human-machine composite subject of scientific text. Firstly, four different translations are quantified by means of questionnaire survey according to the basic standards of Chinese-English translation. Then, the quantitative data is evaluated by Gaussian kernel function and polynomial kernel function. The results show that, on the one hand, the translation qualities of machine translation, professional translator and scientific researcher approximate to form an equilateral triangle in two-dimensional evaluation space, which indicates that the qualities of the above three translations is independent of each other in terms of evaluation space, and the translation quality of computer-aided scientific researcher is closest to the translation quality of professional translator; on the other hand, when the evaluation space dimension is reduced to one-dimensional, Gaussian kernel function can still get similar result, but polynomial kernel function gives different result when its order is greater than a certain threshold.**

Keywords-computer-aided translation; human-machine composite; quantitative evaluation; KPCA

I. INTRODUCTION

As a part of the future translation ecology, the computer-assisted translation practices for various translators will be an important basis for the development of related technologies. Therefore, how to evaluate the translation quality of human-computer composite subjects effectively has become one of the research hotspots in computer-aided translation field.

In 2005, the General Administration of Quality Supervision, Inspection and Quarantine issued the National Standard for Quality Requirements for Translation Services [1], which defines the concept of translation quality in general. That is, the translation should be able to meet the customer's explicit requirements or the objective requirements in practice. Besides the official standards, scholars have done a lot of studies in this area. In foreign countries, House and others made a detailed review of the translation quality assessment (TQA) and discussed the several popular TQA methods, including psychosocial methods, response-based methods, discourse and discourse-based approaches and functional pragmatism [2]. In China, the TQA problem have also been studied based on, for instance, functional theory model [3] and relevance theory model [4], etc.

Although there has been a long research history, the evaluation of translation quality still mainly relies on the subjective evaluation of the similarity between system translation and reference translation. At the same time, the objective quantitative evaluation is not fully developed yet, for example, limited to very few evaluation indexes [4], or carry out evaluation practice for only a single subject [5]. This makes the current studies difficult to adapt to the trend of increasing sample dimensions and non-linear factors brought by the refinement of the index system and the deepening of data mining in the translation quality evaluation practice. Therefore, in the data age, the use of more advanced data analysis methods is necessary to improve the translation quality evaluation of human-machine composite subjects.

To this end, based on the kernel principal component analysis (KPCA) [6], this paper establishes an approach for evaluating the translation quality of human-machine composite subjects. Taking Chinese-English translation as an example, four different translations of the same source text were selected. After obtaining the quantitative data of the index system, the evaluation is carried out by using Gaussian kernel function and polynomial kernel functions. The results illustrate that the presented evaluation method can not only adapt to the practice of translation quality evaluation for composite subjects, but also clearly clarify the translation quality relationship between composite subjects and single subjects. In addition, the higher parameter robustness makes the Gaussian kernel function more suitable for this task.

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II. Evaluation Indexes and Quantization

A. Evaluation Indexes

In order to evaluate the translation quality comprehensively, the ALPAC evaluation standard and the EU evaluation standard are applied to create a two-level index system, which includes three first-level standards and fourteen second-level indicators, as shown in Table I.

TABLE I. Translation Quality Evaluation Index System

Second-level Indicator	First-level Standard		
	Language(S1)	***Text(S2)***	***Economy(S3)***
1	Terminology	Cohesion	Correction time
2	Lexical collocation	Coherence	
3	Sentence structure	Intentionality	
4	Senmantic coherence	Acceptability	
5	Grammatical errors	Informativity	
6	Translation errors	Contextuality	
7		Speed of understanding	

B. Quantization

After determining the index system, it is necessary to design a suitable quantification method to obtain translation quality evaluation data.

First of all, we select "Chapter II Foundation Treatment Construction Technology" in the book "The Construction Technology for Regeneration of Old Industrial Buildings" [8] as the source text, and hand it over to computer-assisted scientific researchers (based on SDL Tradors Platform), machine (an online translation platform), professional translators, and scientific researchers without assistance from any translation platform. The resulting English translations are recorded as Text1, Text2, Text3, and Text4. Among them, Text1 is the translation of a composite subject, and the others are the translations of three different single subjects.

Secondly, the evaluation data is obtained by the implementation of a questionnaire survey. The four English translations are the submitted to two professional groups for evaluation. One has 10 professional translators and the other has 10 related scientific researchers for evaluation. The evaluation values of these two groups were recorded as E1 and E2, respectively. The evaluation of each index is divided into five grades of excellent, good, medium, just passed and failed, and the corresponding score value is gradually reduced from 5 points to 1 point. Generally, the appraiser can directly choose one of these levels, or give other appropriate score within this range.

Finally, the obtained scores are arithmetically averaged and normalized to obtain the index quantified data.

III. Quality Evaluation Process

A. KPCA

From the perspective of data analysis, the quantification process can offer two sets of evaluation data, and each set contains four fourteen-dimensional sample. Although higher dimensionality brings a better performance to describe the characteristics, the higher the dimensionality is, the more difficult it will be to classify and evaluate these samples. Hence, KPCA is utilized here to facilitate the following quality evaluation process.

The basic principles and advantages of KPCA will not be repeated here, and please refer to the related literature. Next, we will use Gaussian kernel functions and polynomial kernel functions to classify and evaluate the translation qualities of different subjects.

B. Gaussian Kernel Function

Gaussian kernel function is a commonly used kernel function with the following expression

$$K_1(x, x_i) = \exp\left(-\frac{\|x - x_i\|^2}{2\sigma^2}\right) \tag{1}$$

where x and x_i are two data vectors, $\|\cdot\|$ represents the Euclidean distance, and σ is an adjustable parameter.

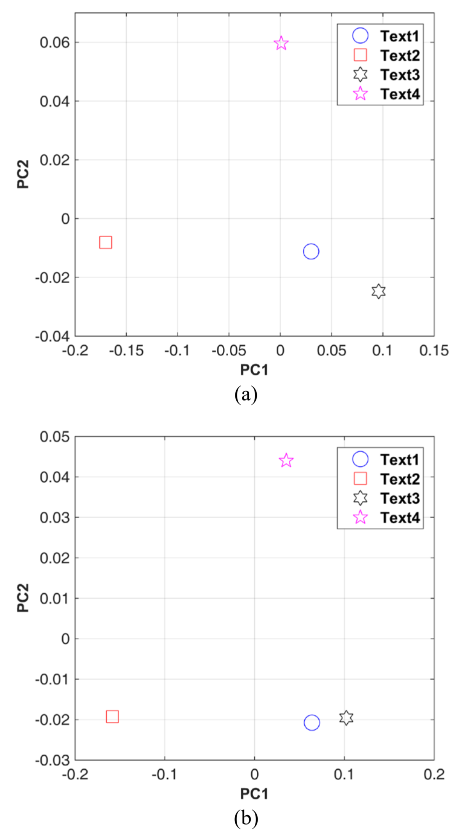


Figure 1. Quality evaluation based on Gaussian kernel function in two-dimension evaluation space: (a) professional translator evaluation (E1); (b) scientific researcher evaluation (E2).

To begin with, the quality of different translations is classified and evaluated in a two-dimensional space, denoted as PC1 and PC2. The parameter σ is set to 6, and the result is shown in Fig.1. We notice that the distance between the translation qualities of the three single-subject translations are basically the same in the evaluation space, and approximately forms an equilateral triangle. Therefore, it can be considered that the quality of the above three translations is independent of each other and belongs to three different translation styles. As a result, this equilateral triangle can be utilized as a frame of reference to evaluate the quality of the translation of the composite subject. Under this reference frame, it can be found that the translation quality of human-machine composite subject is closest to the translation quality of professional translators, which means that through computer assistance, scientific researchers can approach the level of professional translators in the writing of technical English.

Then, the dimension of the evaluation space is reduced to one, and the evaluation results are displayed in Table II. In order to compare the evaluation results in a more intuitive way, the data in Table II is visualized in a two-dimensional space, i.e., PC2=0.1 for E1 and PC2=-0.1 for E2, as shown in Fig.2. It can be seen from the figure that the translation qualities of machine translation, professional translators, and non-computer-assisted scientific researchers can still be considered independent with each other, and the quality of computer-assisted scientific researchers moves towards professional translators compared with its non-computer-assisted correspondence. This is generally consistent with the evaluation results in two-dimensional space, except that, the evaluation value of Text1 is closer to the evaluation value of Text4, instead of Text3.

TABLE II. QUALITY EVALUATION BASED ON GAUSSIAN KERNEL FUNCTION IN ONE-DIMENSION EVALUATION SPACE

Valuator	Evaluation			
	Text1	*Text2*	*Text3*	*Text4*
E1	0.0302	-0.1701	0.0960	0.0011
E2	0.0638	-0.1582	0.1022	0.0351

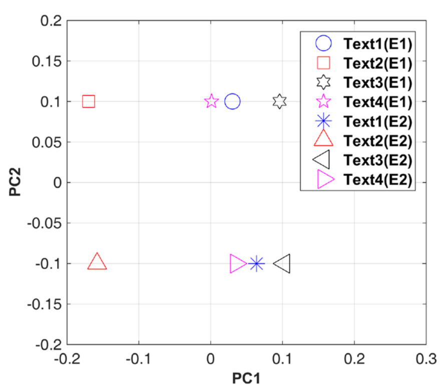


Figure 2. Visualization for data in Table II.

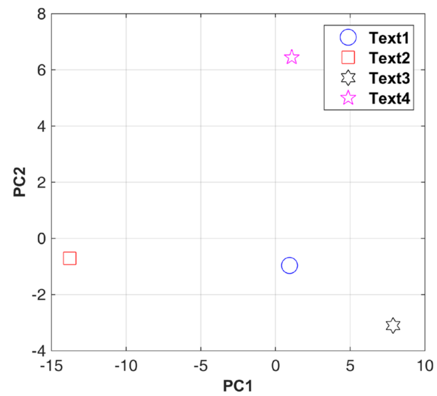
Finally, more simulation experiments are performed and it suggests that the value of σ mainly affects the specific evaluation values of the four translations, but the overall impact on the evaluation conclusions is very small.

C. Polynomial Kernel Function

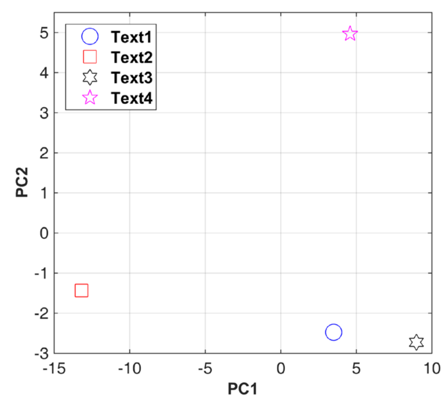
In addition to the Gaussian kernel function, the polynomial kernel function is

$$K_2\left(x, x_i\right)=\left(x^T x_i+1\right)^d \tag{2}$$

where the superscript T indicates transpose, and d is an adjustable parameter that controls the order of the polynomial. As before, the evaluation starts in a two-dimensional evaluation space with d equals to 3, and the results are displayed in Fig. 3.



(a)



(b)

Figure 3. Quality evaluation based on polynomial kernel function in two-dimension evaluation space: (a) professional translator evaluation (E1); (b) scientific researcher evaluation (E2).

As shown in the figure, the relative minimum distance between the evaluation values of Text1 and Text3 indicates that the computer-assisted scientific researcher has similar translation capacities with the professional translators, which is consistent with the previous evaluation results based on Gaussian kernel function. The visualization for the evaluation data obtained by using polynomial kernel function in one-dimensional evaluation space is illustrated in Fig. 4.

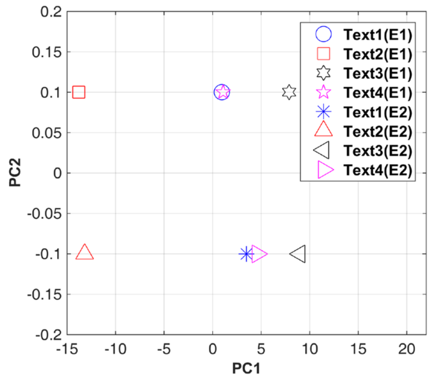


Figure 4. Quality evaluation based on polynomial kernel function (*d*=3) in one-dimension evaluation space.

When the polynomial order is 3, the evaluation value of Text1 moves toward the evaluation value of Text2. This is not only contrary to the previous conclusions of Gaussian kernel function, but also different from the evaluation results in two-dimensional space with the same order polynomial kernel function.

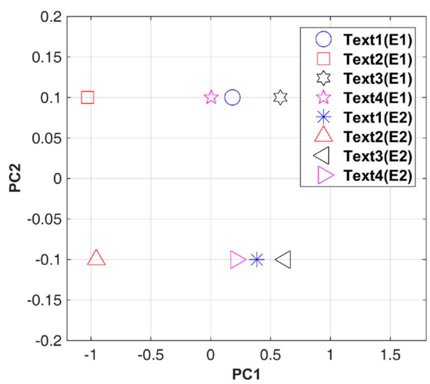


Figure 5. Quality evaluation based on polynomial kernel function (*d*=1) in one-dimension evaluation space.

To further analyze this phenomenon, the polynomial order is set to be 1 in Fig. 5. Different with that in Fig.4, the evaluation value of Text1 moves toward the evaluation value of Text3, which is consistent with the evaluation based on Gaussian kernel function in tow- and one-dimensional spaces, and the evaluation of the third-order polynomial kernel function in two-dimensional space. More numerical simulations found that when the order of the polynomial is greater than 2 for one-dimensional evaluation space, and 8 for two-dimensional evaluation space, the evaluation value of Text1 will be closer to that of Text2.

Objectively, it is a very difficult challenge to determine the order of the polynomial kernel function a priori in the practice of translation quality evaluation, just as in other tasks [9]. At the same time, surveys of relevant personnel show that the evaluation results based on Gaussian kernel functions and lower-order polynomial kernel function are more in line with the common subjective understanding. Therefore, this paper believes that, compared with polynomial kernel function, Gaussian kernel function are more suitable for the classification and evaluation of the translation quality of scientific and technological texts in different evaluation space dimensions.

IV. Conclusion

In this paper, the translation quality classification and evaluation of human-machine composite subject is carried out based on the two-level index system and the KPCA algorithm. Numerical simulation results demonstrate that the presented method can reflect the quality relationship between translations of different subjects. In addition, because of the better parameter robustness in different evaluation space, it is recommended to use the Gaussian kernel function in KPCA to evaluate the translation quality of human-machine composite subjects.

Acknowledgment

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