Constructing the Image Graph of Tang Poetry

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Abstract. Images are the soul of poetry. The usage of images enables poetry to express its deepest emotions in very concise expression. While the structured language of poetry bring convenience to computer processing, the accumulation of a large number of images also brings difficulty to deep semantic understanding. Starting from the definition of object imagery, this paper selects 304 Tang poems as experimental samples, extracts the object images from poems. Then it calculates the emotional tendency of object images according to the emotion system. Finally, it calculates the similarity between images to achieve the relevancy between the images and establishes the map of image relationship. This paper presents the relationship between images using visualization methods, which would help poetry learners understand the images intuitively, and provide reference for correlation study of Tang poetry.

Keywords: Image, Tang poetry, Poem graph.

1 Introduction

The application of computer technology in literary research not only overcomes the shortcomings of traditional literary research like time-consuming and high cost, but also makes the research results more objective. As a result, computer assisted Chinese traditional literary research has been paid more and more attention as the natural language processing technology develops rapidly.

Compared with novels, dramas and other literary forms, poetry have a more stable structure. After over 20 years of development, computer-aided poetry research has made remarkable achievements in fields of resource base establishment, text classification, etc. Hu and Yu developed a computer-aided research system for Tang and Song poems based on the corpus of Tang and Song poems consisted of more than 6 million words [1]. The system improved the poems retrieval and realized automatic phonetic notation of Tang poems. Hu and Zhu took the text, title, authorship and style of poetry into account, classified the topics of Tang poetry automatically and achieved optimal classification results [2]. Yi proposed the model that distinguished the poems with graceful style from the bold poems. The work could be seen as a variation on the poetic topic classification [3].

Knowledge graph aims to simplify information access, reveal knowledge structure and help knowledge development through data mining, analysis, classification and mapping [4]. In recent years, some institutions and researchers have made attempts to construct the knowledge map of poetry. The poetry portal Souyun has established a chronological map of Tang and Song literature and a map of the geographical distribution of poets in successive dynasties [5]. Zhou put forward a series of conceptions for constructing the Tang poetry knowledge map [6]. As we can see, these work focus more on the visualizing the external knowledge rather than the internal knowledge of Tang Poetry. In other words, the present visualization of Tang poetry lacks fine-grained knowledge relations, such as the relationship between themes and images.

Some researchers also attempt to explore the knowledge of Tang Poetry in deep level: Hu used the context-based vector space model(VSM) to describe the semantics of words approximately, so that to calculate the semantic similarity between words of poetry [7]. Li clustered the poetry images, then took images of poetry as classification features [8]. Inspired by the previous work, this paper attempts to use VSM to express the affective disposition of each image, calculate the similarity between images and establish the image map of Tang poetry.

2 Our Method

To construct the image graph of Tang poetry, we have to define the image firstly. Considering different scholars have different opinions on the definition of image, the image in this paper is consistent with Yuan Xingpei's point of view [9]. That is to say image is an object image which integrates subjective feelings, or a subjective emotion expressed by objective objects. Strict and regular style of Tang poetry makes it use words concisely. Authors of poems often chooses the most appropriate “object image” (“象”) to express his “meaning” (“意”) in short five-character or seven-character sentences. For example, the sentence “Straight smoke above desert, sunset above long river” (“大漠孤烟直，长河落日圆”) combine four object images: “desert”, “smoke”, “long river” and “sunset” to create a desolate and lonely mood. In this sentence, four object images are contaminated with lonely feelings of the whole poem and tend to be images of loneliness. This chapter describes the image map construction through four parts: classification system of poetry emotion, pretreatment, image representation and image similarity calculation.

2.1 Classification System of Poetry Emotion and Data Source

As mentioned above, an object image with the author's subjective emotion is the image. Therefore, we can regard the classification of images as the classification of poetry emotion, the object images in the poems with same emotion will be contaminated with the same emotion and tend to fall into the same category. However, because the emotion is complex and hard to measure, the classification of emotion will inevitably have confusing and overlapping problems. Zhu [10] thought that the classification of poetry emotion or style is inseparable from the classification of human emotion, it

drew on the three-dimensional theory put forward by Wundt [11], took pleasure-unhappiness, calmness-excitement, tension-relaxation as dimensions and the emotion of poetry were divided into 12 categories: depression, ease, sadness, cheerfulness, excitement and so on. Considering that the difference between tension and excitement, relaxation and calmness in poetry is relatively minor, this paper defines 4 emotions of poetry by taking pleasure-unhappiness as the main yardstick, then thinks about the dimension of calness-excitement. The classification of poetry is shown in Table 1.

Table 1. Emotion system of Tang poetry

	Pleasure	Unhappiness
Calmness	tranquil	passionate
Excitement	melancholy	grief

According to the emotion classification in Table1, we select poems from Three Hundred Tang Poems for artificial emnotion annotation. We got 304 Tang poems as experimental samples and the distribution of categories are as follows: 67 tranquil poems, 47 passionate poems, 143 melancholy poems, and 47 grief poems.

2.2 Pretreatment of Experimental Samples

According to the definition of images, we must select the object images from poems to acquire images. And in order to get the object images in poetry, we should first pretreat the samples of poetry, including word segmentation and object image extraction. There are some differences of the word definition between ancient poetry and modern Chinese. For example, in modern Chinese, “Chang he” (长河), “Xian yun” (闲云), “Bai yun” (白云) and others like these are regarded as phrases, but to be regarded as words in Tang poetry which makes the word vocabulary of modern Chinese is not suitable for Tang poetry segmentation. Most Tang poems are modern-style poems (referring to innovations in classical poetry during the Tang Dynasty), and their rigorous and regular rhythmic structure brings us a new approach for Tang poetry segmentation. Firstly, we divide each five-character clause into “two-two-one-character” clause, and the seven-character clause into “two-two-three-character” clause, for instance, dividing “白日依山尽” into “白日/依山/尽”, dividing “芳草萋萋鹦鹉洲” into “芳草/萋萋/鹦鹉洲”. Then, we reserve the bigrams with frequency higher than 5 and the trigrams are segmented by these bigrams to get a new one-character and two-character word vocabulary. Finally, we reserve three-character words with frequency higher than 3, combine the one-character, two-character and three-character word list to get the final Tang poetry vocabulary. In view of the fact that the final word list will retain phrases such as “Yuan Ti” (猿啼) and “Yan Fei” (雁飞), which will introduce nosie during the extraction of object images, we combine the pyhanlp word segmentation tool and Tang poetry word vocabulary to segment the Tang poems.

To the step of extracting the object images, we need to further refine the definition of object image. The object of object images in this paper refers to the the name or de-

scriptions of things, nouns such as “Xian yun” (闲云), “Ming yue” (明月) can be regarded as images, while verbs such as “Chou chu” (踌躇), “Du zuo” (独坐) as well as time nouns such as “Xi nian” (昔年), “Jin ri” (今日) will not be regarded as images. After removing the noise artificially, samples of the object image are shown in Table 2.

Table 2. Object images extracted from Tang poems

Authorship	Title	Object images
张九龄	感遇	兰叶 春 桂华 秋 生意 自尔 佳节 林 栖者 风 草木 本心 何求 美人
王维	渭川田家	斜光 牛羊 野老 牧童 荆扉 雉雊 麦苗 蚕眠 桑叶 田夫 荷锄 语依依
孟浩然	夏日南亭怀辛大	山光 池月 东 荷风 香气 清响 知音 感此 故人 中宵 梦
陈子昂	登幽州台歌	古人 来者 天地 涕
王湾	次北固山下	客路 青山 行舟 绿水 潮 两岸 风 海日 残夜 江春 旧年 乡书 何处 洛阳 边

2.3 Image Representation

Just as the relationship of character symbols and meanings are multi-directional, the relationship between object images and emotions in poetry is not one-to-one correspondence. That is, the same emotion can be expressed with different object images, the same object image can also represent different emotions. For example, “美人” (beauty) represents poeple as an object image, in sentence “美人卷珠帘，深坐蹙蛾眉”, the “Beauty” is a woman image full of loneliness, but in “战士军前半死生，美人帐下犹歌舞” the “Beauty” is a Lost warf-Kingdoms image to express the sadness and grief of the author. It can be seen that the same objective object image of “美人” in poems with different emotions represents different images and the more categories an object image appears in, the more complex the image it represents.

Vector Space Model (VSM) is one of the most widely used text representation models. It can transform text content into vectors and express the similarity between texts according to the distance between vectors. For example, the text d is represented in vector space model as equation (1).

$$V(d) = (W_1, W_2, \cdots, W_n) \tag{1}$$

Where $W_i (1 < i < n)$ is the weight of the feature i, and its value represents the ability to represent the text d. Work [8] used VSM model to describe poetry object images, but the proportion of a certain emotion category in the total experimental samples was not considered during the calculation of emotion propensity. For the image with complex emotion, it is easier to incline to the emotion category with larger samples. This paper also uses VSM to represent images approximately, as in equation (2), each object image is represented as a vector, and each dimension of the vector represents the tendency of the image to a certain emotional category.

$$Im = (t_1, t_2, \cdots, t_n) \tag{2}$$

Where n represents the number of emotional categories, $t_i (1 < i < n)$ is the tendency of image Im to this emotional category, which is calculated by equation (3).

$$t_i = \frac{F_i}{\sum_{k=1}^{n} F_k} \times \frac{1}{n_t} (\log \frac{N}{d_{t_i}}) \tag{3}$$

In equation (3), F_i denotes the occurrence frequency of image Im in the emotional category i in the samples of experiment. $\sum_{k=1}^{n} F_k$ denotes the total occurrence frequency of image Imappears in the samples of experiment. N is the total number of poems and d_{t_i} is the poem number of the emotion represented by dimension t_i. n_t is the number of emotion category.

According to the method mentioned above, the extracted object images can be transformed into vector forms. Some examples are shown in Table 3.

Table 3. Samples of image emotional tendency

Image	Affective Disposition			
	tranquil	passionate	melancholy	grief
美人	0.095	0.117	0.071	0.060
白云	0.142	0.058	0.095	0
杨柳	0.095	0	0.142	0
梦	0	0.052	0.148	0.027
雨	0.087	0.108	0.058	0.074

As we can see, the more non-zero dimensions an image has, the more complex its emotion will be. For example, images "美人" (beauty), "雨" (rain) has all emotion labels, the two object images are both inclined to passionate and tranquil emotions. On the contrary, the image "杨柳" (willow) only appears in the poems with melancholy and tranquil labels, and its emotional tendency is relatively pure.

2.4 Similarity computation of image

In Section 2.3, we use the vector space model to represent the image as a vector in the vector space. Based on the two vectors, we can calculate the similarity by Eucledian Distance, Pearson Correlation Coefficient, Cosine Similarity, etc. In this paper, cosine similarity is used to calculate the similarity between images. The calculation equation is shown in (4).

$$\cos(Im_1, Im_2) = \frac{\sum_{i=1}^{n} Im_{1i} \times Im_{2i}}{\sqrt{（\sum_{i=1}^{n} (Im_{1i})^2）（\sum_{i=1}^{n} (Im_{2i})^2）}} \tag{4}$$

where Im_1 and Im_2 represent the affective disposition of two images, n is the dimension of vectors, Im_{1i} and Im_{2i} are tendencies of dimension i in Im_1 and Im_2 respectively. The larger the cosine value between two images, the more similar the two vectors are.

By calculating the cosine similarity, we can get the similar relationship between the images. Some image samples and ten of their most similar images are listed in Table 4.

Table 4. Similar images TOP10 calculated according to emotion tendency

Image	Similar images（TOP10）
明月	春 心 烟 月明 芳草 杜鹃 杨柳 两岸 南山 游子
雁	水 树 髻 月 羽 园 波澜 淮 宫 路
美人	雨 后 落日 草 衣裳 声 春风 风 钟 舟
将军	征人 大漠 青冢 古来 去时 国 胡儿 病 汉将 歌声
泪	雁 洛阳 少妇 故乡 孤城 长江 音书 尘 殿 消息

Of course, we can also obtain similar images of one certain image by other methods. Word2vec is a tool for natural language processing released by Google in 2013 [13], it vectorizes all words to quantify the relationships between words. In this paper, word vectors are trained on the basis of extracted object images and the similarity between images is also calculated by cosine similarity. The results corresponding to Table 4 are shown in Table 5.

Table 5. Similar images TOP10 calculated according to word2vec

Image	Similar images（TOP10）
明月	风 月 君 万里 下 山 心 泪 中 梦
雁	上 秋 春风 城中 霜雪 长安 闲暇 山石 琵琶 省中
美人	家 春 客 声 上 水 琵琶 马 心 将军
将军	声 人 月 客 时 风 心 泪 何处 中
泪	人 客 水 君 上 声 时 夜 何 明月

As we can see in Table 4, the more emotion categories an image involves in, the more complex emotion its similar images will be. For instance, the image “将军” (general) appears in the poems of passionate, melancholy and grief emotion, and its similar image “征人” (a traveler on a long journey), “大漠” (desert), “男儿”(man) also contains passionate, melancholy and grief emotion. It can also be said in this paper what the emotion tendency calculates is the similarity of emotion complexity between images.

The affective disposition of similar images obtained by word2vec method is simpler. As Table 5 shows, the images similar to the “将军” (general) is more inclined to the emotional color of melancholy and grief but lacks images related to the passionate emotion. This is because the emotion of Tang poetry is often complex and changeable, sometimes the first couplet depicts a tranquil scene while the tail couplet can not hide melancholy of the author. Compared with the method proposed in this paper, word2vec focuses more on the context information of target image, which can better capture the changes of internal emotion of poetry, but fail to grasp the overall emotional tone of poetry. The two image representations both have their own advantages and disadvantages and they can be applied to researches according to different tasks.

3 Visualization

With image representation, we can cluster the images of Tang poems and construct an image Graph. We use the Embedding Projector to map images firstly. Embedding Projector is a tool included in TensorBoard for visualizing embeding [14]. PCA algorithm is used for image dimensionality reduction, the intuitive distances of points close to high-dimensional distances. Figure 1 takes the image “将军” as an example and selects 100 nearest neighbors to visually show the distribution of images.

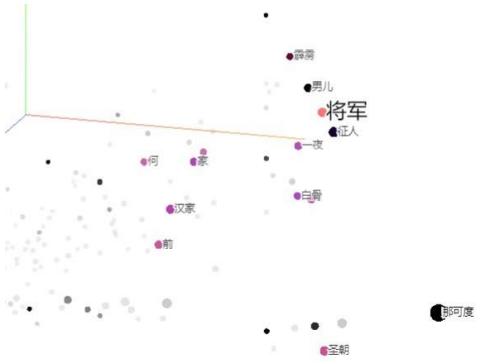

Fig. 1. Image distribution (takes the image “将军” as an example).

In order to inspect the emotional transition between images, we use networkx [15] to construct an object image network graph by assuming the first 500 images and their most 10 similar images are nodes, and adding edges between similar images. Figure 2 is a partial intercepted graph.

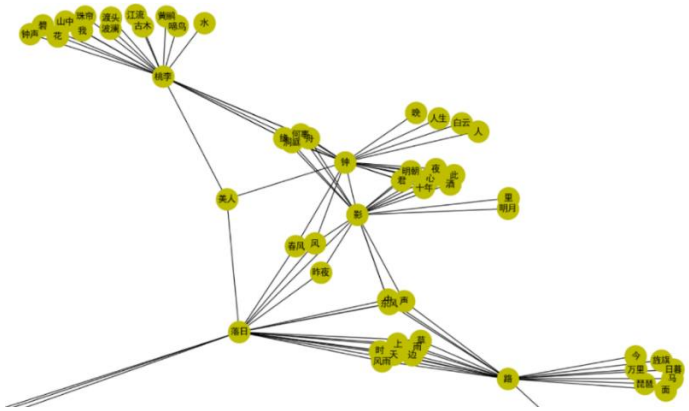

Fig. 2. Partial network of Tang poetry images.

The images with complex emotions often assume the role of the transients. For example, in Figure 2, “桃李” (peaches and plums), “钟” (bell), “影” (shadow), “落日”

(setting sun) and “路” (road) are central nodes, each emits 10 similar images. “桃李” (peaches and plums) is a pure tranquil image, but its similar images “洞庭” (Dongting), “舟” (boat) expand the network to an images more inclined to melancholy emotions because they contain melancholy emotions. Image “美人” (beauty) connects three image nodes whose emotion are more complex than other images in the Figure 2.

4 Conclusion and future work

Image is the key to interpret poetry texts and emotions of authors. Using the definition of image as a clue, this paper selects poems from Three Hundred Tang Poems as experimental objects to extract object images. Since the definition of image is the object image with the author's subjective emotion, we calculate the affective disposition of the object image, then calculate similarity between the images according to the affective disposition. Finally, we cluster images and construct the image graph based on image similarity to visualize the similar relationship between images.

Of course, we still have a lot of work to do:

- Firstly, image and poetry quantity involved in Three Hundred Tang Poems is limited, which will affect the accuracy of calculating the image emotion tendency. We have also used text classification method to extend the experimental data, but the poetry sentiment classification task is difficult to obtain convincing accuracy, which limits the scalability of the data.
- Secondly, some noise will be introduced during the extraction of object images.
- last but not least, happiness is alike in happy family, while different in those unhappy. In the actual annotation, we can feel that the poetry emotion of the unhappiness is more complicated than the pleasure dimension, it is also worth considering whether the emotion classification system should be further refined.

All these problems need to be solved in our future research, we also expect there will be more scholars focusing on the research of Tang poetry’s deep-seated semantic computing.

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