Adaptive Image Retrieval Based on Multi-Feature Fusion

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Abstract. With the rapid development of technology and the popularity of the Internet, a large number of image datasets have been produced in various industries. It is difficult to quickly search for a desired image in a large number of image datasets, so it is very meaningful to design an efficient image retrieval system. This paper proposes an adaptive weighting method based on information entropy. Firstly, the trust of a single feature is obtained according to the information entropy. Then the transfer matrix is constructed according to the trust of a single feature, and the weight of the single feature is obtained by iterative calculation according to the transfer matrix. This method has the following advantages: (1) The retrieval system combines the performance of multiple features and has higher accuracy than the retrieval of a single feature; (2) In the query process, the weight of the individual features is dynamically updated using the query image, so that the retrieval system takes full advantage of the single feature. The experimental result shows that the proposed method is better than the previous method. The Mean Average Precision of the search on the Holidays image dataset is 83.99%.

Keywords: Image retrieval, adaptive, multi-feature fusion, information entropy.

1. Introduction

With the continuous development of Internet technology, images have grown dramatically as a medium for intuitively expressing information. It has always been a challenging task that how to quickly and accurately retrieve the images that users want in massive images. Therefore, image retrieval technology has become a research hotspot in the computer field, and an efficient image retrieval system has emerged. There are two common image retrieval systems: text-based image retrieval system and content-based image retrieval system [1]. Text-based image retrieval system requires experienced experts to mask images[2],which is very expensive and time-consuming. Content-based image retrieval is the most common method, It can be divided into two categories [3]: One is a global feature based on a hash strategy index; the other is a local scale invariant feature based on a lexical tree or a k-d tree index. These two features have their own advantages and disadvantages, and their performance complements[4-5]. In recent years, in order to improve the accuracy of image retrieval, people have done a lot of excellent work. In the paper[4], a dynamically updated adaptive weight assignment algorithm (AWAA) is proposed, which distributes the fusion weight proportional to the matching contribution, which helps us obtain more useful images in the feature fusion process. In the paper[6], a graph-based query feature fusion method is proposed, in which multiple search sets are merged and reordered by link analysis on the fusion map. The fusion map can adaptively combine the advantages of the retrieval method. Make different queries without any supervision. In the paper[7], a simple and effective fusion method based on fractional curve is proposed, and different features are weighted in a query adaptive manner.

Although the above method has achieved good results, there is still room for improvement in the retrieval performance of the retrieval system. In order to improve retrieval performance, it is an effective image retrieval strategy to fuse multiple features[8-11]. The method of retrieving each feature by feature weights at the measurement level has been widely used, but how to determine the weight of each feature is still a very important issue [7，10]. In the paper[6], a graph-based query-specific fusion method without any supervision is proposed. In the paper[7], the weight of the feature is calculated using the retrieval score curve of a single feature. In the paper[9], an adaptive strategy based on information retention is proposed. The weight of each feature is adjusted by the influence of environmental changes on features and the contribution of different features. In the paper[11], based on the general index tree (GIST) feature retrieval, the scale invariant feature transformation (SIFT) feature retrieval is used in the retrieval results, and the final result is returned. Different weights determine the performance of the retrieval method, and the adaptive weight has better retrieval performance than the global weight. In order to further improve the retrieval performance, this paper proposes an entropy-based adaptive weight determination method for merging multiple features. This method has the following advantages:(1)The image retrieval system combines the performance of multiple features, and has better retrieval accuracy than single feature retrieval;(2) In each query, the query image is used to dynamically change the weight of each feature to fully utilize the performance of a single feature for retrieval. Firstly, the trust degree of a single feature is obtained by information entropy; then, the trust matrix is constructed based on the trust of a single feature; finally, the weight of a single feature is obtained by iterating based on the transfer matrix. The image retrieval system makes full use of the individual feature information of the image can improve the accuracy of the search.

2. Related Technical Knowledge

2.1 Image Retrieval Process.

Basically, the process of all multi-featured image retrieval systems is similar, and the process is as follows[10-14]: Firstly, several features of each image in the image set are respectively extracted to create an image feature library; then, when the user inputs the query image, the similarity between the query image and the image in the database is calculated based on several features respectively; The similarity is weighted to obtain a comprehensive similarity measure, and the search result is output based on the measure.

2.2 Feature Extraction.

In this paper, the convolved neural network method is used to extract the convolution characteristics of the image using the trained VGG-16, GoogleNet and ResNet models. Features of all images are extracted and saved in the image feature database in the form of "image names, features". When we perform image retrieval, we compare the features of the query image with the features of the image feature database.

2.3 Information Entropy.

Information entropy[15-16] was first given by Shannon, which is expressed as a probability distribution function of random variables. Information entropy mainly includes symmetry, non-negative, certainty, scalability, additivity and extreme value. Its definition is expressed as:

$$\mathrm{E}(x) = -\sum_{i=1}^{n} p_x \log_2 p_x \tag{1}$$

Here, x is a random phenomenon, and p_x is the probability of x.

2.4 Weight Determination Method.

In order to make full use of the performance of single features to improve the accuracy of retrieval, a new feature fusion method suitable for measurement level is proposed in this paper. First, the trust of a single feature is obtained based on entropy; then, a trust-based transfer matrix is constructed; finally, based on the transfer matrix, the weight of a single feature is obtained through multiple iterations. This can make full use of the single feature information of the image, and thus achieve higher retrieval accuracy.

3. Adaptive Weighting Strategy.

When performing image retrieval, the calculation of the adaptive weight is performed in accordance with the following steps. Input an image to be queried, extract different features of the image, and calculate the distance from the features saved in the feature library to obtain several sets of distance $D_i(q)=(d_i(1),d_i(2),...,d_i(n))$. After getting the distance, you can calculate the entropy of the distance. Expressed by the following formula

$$E_i=-\frac{1}{\log_2 n}\sum_{j=1}^{n}\frac{d_i(j)}{\sum_{j=1}^{n}d_i(j)}\log_2\frac{\sum_{j=1}^{n}d_i(j)}{d_i(j)} \tag{2}$$

Here i represents each feature, n is the total number of images, and $d_i(j)$ represents the distance between the query image and the $j-$th image in the feature library. The resulting entropy is the trust of each feature. Then construct the transfer matrix $M=\{M(x,y)\}$ according to the trust of each feature, as follows:

$$\begin{aligned}&if\quad E_y>=E_x\\&\quad M_{(x,y)}=e^{\alpha(E_y-E_x)}\qquad(\alpha\geq 1)\\&else\\&\quad M_{(x,y)}=\left|E_y-E_x\right|\end{aligned}$$

The weight of each feature is calculated using a transfer matrix. First initialize the weights $w_1=\{\frac{1}{m},\frac{1}{m},...,\frac{1}{m}\}$, $w_d=\{w_{F_1},w_{F_2},...,w_{F_m}\}$ is a collection of m feature weights. w_d is the new weight obtained by iteration. w_{d-1} is the weight of the previous iteration. The transfer matrix $M=\{M(x,y)\}$ is used to iterate the weights, and the iteration formula is as follows

$$w_d=\gamma w_{d-1}+(1-\gamma)Mw_{d-1},(\gamma\in[0,1])$$

The iterative algorithm is as follows

$$\begin{aligned}&w_d=\{\frac{1}{m},\frac{1}{m},...,\frac{1}{m}\},\quad d=1\\&until\quad\left\|w_d-w_{d-1}\right\|<\varepsilon\quad(\varepsilon>0)\\&do\\&\quad w_d=\gamma w_{d-1}+(1-\gamma)Mw_{d-1}\quad(\gamma\in[0,1])\\&\quad w_d=w_d/sum(w_d)\\&return\quad w_d\end{aligned} \tag{3}$$

4. Experimental Results and Analysis

4.1 Experimental Dataset and Evaluation Criteria.

In the experimental study of this paper, the image dataset used:

Holidays consists of a total of 1491 holiday travel photos in 500 categories. Use mAp as the evaluation criteria for the search.

4.2 Experimental Results and Analysis.

In order to verify the validity of the adaptive weighting method proposed in this paper, we conducted experiments on the Holidays dataset. Table 1 shows a comparison of search results based on AVG and OURS. As can be seen from Table 1, on the Holidays image dataset, our method's retrieval accuracy is 5.27% higher than AVG. The effectiveness of the proposed method is verified.

Table 1 Comparison of search results based on AVG and OURS (mAp)

	AVG	OURS
Holidays	78.72%	83.99%

Fig. 1 is a random selection of an image as a query image on the Holidays data set, using the method of this article to obtain the first 10 search results.

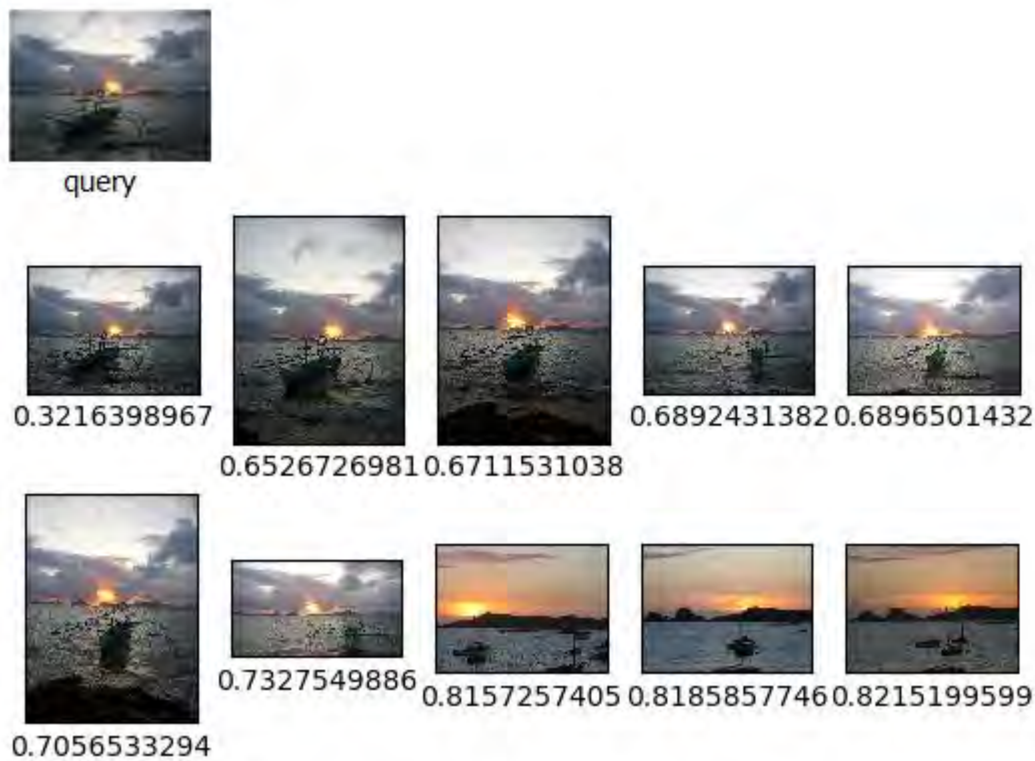

Fig. 1 Search results of the method in the Holidays data set

5. Conclusion

Image retrieval with multiple features can effectively improve the retrieval accuracy. At the same time, proper single feature weights can help to further improve retrieval performance during the fusion process. This paper proposes a method for calculating single feature weights, which combines multiple features for image retrieval. Through the retrieval experiments on the Holidays image dataset, the conclusion that the method has better retrieval performance is obtained.

Considering that the multi-feature image retrieval increases the retrieval time, in the future work, we will study how to improve the retrieval efficiency. In addition, the idea of image decomposition can be considered to extract closer feature descriptions for image retrieval, which is of great significance for improving the efficiency of the retrieval system.

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