POSTER: A Composition-Based Image Retrieval Using Line Feature

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ABSTRACT

In this paper, we propose an image retrieval scheme that retrieves compositionally similar images with the query image from the line-used image set. To develop a new effective similarity measurement, we use line feature to discriminate in similarity, by investigating the relation between the value of the property and the degree of the compositional similarity. We have developed a similarity measure and compared effectiveness with a simple similarity measure in the sense of recall and precision. Our result proves that proposed scheme provides higher effectiveness.

Keywords

image retrieval, line feature, compositional similarity

1. INTRODUCTION

Image retrieval has been a favorite topic in computer vision research area. Text-based method and visual-based method, for example content-based image retrieval (CBIR), are the example of approaches that used for image retrieval. In content-based image retrieval, color is a common feature that used for retrieval. [Swa91] and [Smi95] used color histogram and color set as a form to represent the color feature. In sophisticated retrieval, spatial features have been considered in as a visual feature. [Lu94], [Smith96], and [Ko02] used the spatial feature by segmented sub-regions and the spatial relations between the sub-regions are considered as visual feature. In the aspect of the photographic composition, a line is basic and important feature which gives viewer specific feelings [Pra06]. Few studies, however, used line feature in image retrieval. [Fra00] proposed matching scheme using line feature but it is restricted in line-drawing images.

In this paper we propose effective image retrieval from the line-used image set. We organize our paper as follows: In section 2, we describe which property of the line is related with compositional similarity and then analysis the relation between the value of the property and the degree of the compositional similarity. Then, we develop a new measure for compositional similarity in section 3. In section 4, we evaluate the performance of the proposed scheme. The experiment shows that proposed scheme gives higher performance in the sense of recall and precision than the basic similarity scheme.

2. COMPOSITIONAL SIMILARITY

In this section, we describe how to find the properties of the line that affect the compositional similarity and then analysis the relation between the value of the property and the degree of the compositional similarity.

We investigated human's subjective retrieval results to define the properties of the line that affect the compositional similarity. Description is as follows:

1. Some query images are given by a user. If the query is compositionally similar with the image in the DB, a vote will be given. The process repeated for all of queries.
2. From the voting result, we compute the degree of subjective similarity for all queries with all images in the DB individually.
3. For each image in the DB, we extract the

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representative line from the image and compute the values of the property (angle, position, and magnitude) of a line.

4. Then we select discriminative property in subjective similarity from the result of 3rd process.

In next subsection, we will explain the process in detail.

2.1 Discriminative Property of the Line

Subject users consist of 13 people, and the number of query images is 8. The each query image has a representative line whose angle ranges separately from 0 to 180 degree (figure 1). The DB is made of images which have a line that is fairly distributed on the angle, position and magnitude.

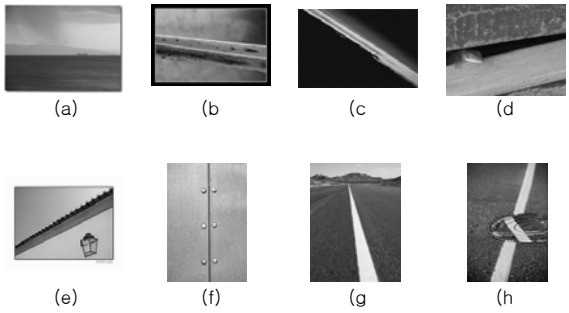

Figure 1. The query images for finding a distinctive property of line

The 13 subject users were given the query images and voted for the DB as the first step of the above process. After voting, we measured the degree of subjective similarity between each query and each image in the DB, as follows:

$$Similarity_{q,t} = \frac{Score_{q,t}}{\sum_i Score_{i,t}} \quad (1)$$

q : index of the query

t : index of the image in the DB

$Score_{q,t}$: the number of voting of image t for image q

Then, we extract the representative line of a image by using Hough transform. Before conducting the Hough transform, we normalized the size of the image, and extracted the edges. Then we transformed the image by the Hough method, so we could get the representative line by finding the maximum value in the Hough transformed image. We modified the voting process in Hough transform so that the higher intensity of the edge, the more voted into accumulation array while the general ways do not consider the magnitude of edge.

After finishing the representative line extraction, we represented each image in the DB as a point in the graph which horizontal and vertical axis corresponds to subjective similarity and the value of one of three properties of line respectively in figure 2. In these three of graphs, we can find that the angle of the representative line reflects distinctiveness of two separate groups that one is similar to a given query and the other is not, while other two properties, position and magnitude do not so. As the results of other query images was also of the same, it would be better not to show all of those results.

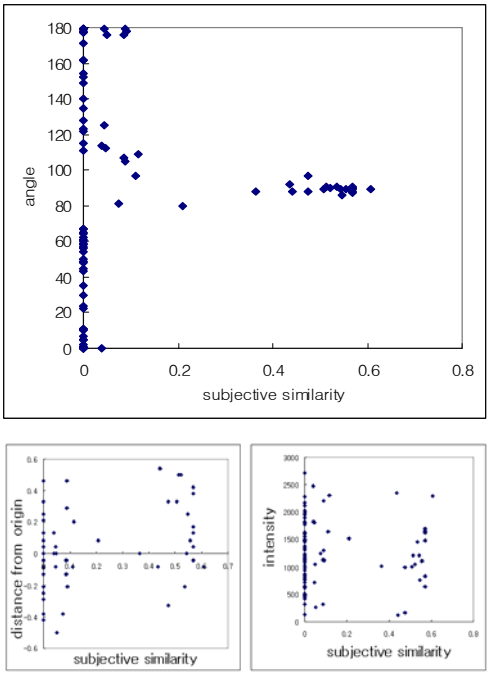

Figure 2. Distribution of the property's values of line of each image in the database

2.2 Distributions of the Angle of Similar Images with a Query Image

The figure 3 illustrates the distribution of the angles of the representative lines included in the images of the group which is the set of images similar to the given query. It points out that if the angle of the representative line of a query image corresponds to horizontal or vertical line, the range of the distribution is narrow comparing to the case of diagonal.

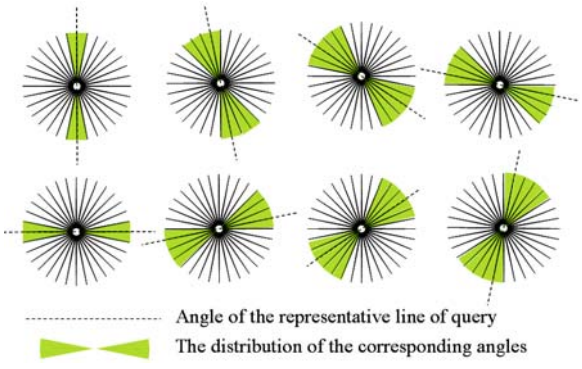

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Figure 3. The distribution of the angles of the representative lines included in the images of the similar images group to the given query

In the case that the representative line is near vertical, the range of the distribution in direction of diagonal side is wide while the range of the distribution in direction of vertical side is narrow. Also, the case of near horizontal line provides the same result. It means that the human recognize the differences sensitively in near vertical or horizontal angles while insensitively in diagonal angles.

3. SIMILARITY MEASURE

In this section, we describe a measure for compositional similarity, which is made based on the observation that the distribution range of the angle of the representative line included in the result pictures for a query is affected by the angle of representative line included in the query.

As mentioned previously in the section of 2.1, it is possible to use the difference of angles for measuring similarity between a query and each image of the DB. However, when using the difference directly, a problem would be occurred. The problem is that images which are not similar to the query image may be included in the retrieval results in the case of the query images that have a near vertical or horizontal line. To resolve this problem, the weight is applied to the difference of angles according to the angle of the representative line of a query image as shown in (2).

$$\text{Distance}(\theta_q,\theta_i)=\begin{cases}|\Delta(\theta_q,\theta_i)|/\mathrm{W}_{ccw}(\theta_q) & ,\text{if } \Delta(\theta_q,\theta_i)\geq 0\\ |\Delta(\theta_q,\theta_i)|/\mathrm{W}_{cw}(\theta_q) & ,\text{if } \Delta(\theta_q,\theta_i)<0\end{cases} \quad (2)$$

The θ_q and θ_i is the angle of the representative line of a query image, *q,* and that of an image of the DB, *i*, respectively. $\Delta(\theta_q, \theta_i)$ is the acute angle from two possible differences of θ_q and θ_i. If θ_i is located toward more clockwise direction rather than θ_q, the sign of the distance is positive, otherwise negative. We designed the weight function, $\mathrm{W}_{cw}(\theta_q)$, that produces smaller value when the θ_q is closer to horizontal or vertical in clockwise direction. The $\mathrm{W}_{ccw}(\theta_q)$ is also same to the $\mathrm{W}_{cw}(\theta_q)$ except the direction.

As shown in the (2), the angles close to horizontal or vertical have their difference divided by relatively small number to react sensitively. On the other hand, the angles close to diagonal have their difference divided by relatively big number to react insensitively. By applying this method for measuring the compositional similarity between images, the results of the search are improved comparing to by using only difference value.

4. Retrieval Effectiveness

For verifying the measure suggested, the simple search system was implemented, and precisions and recalls computed from the results for several query images are compared.

In the search system, a series of the output images for a given query are retrieved sequentially in increasing order on the amount of the similarity. The DB consists of about 100 line-used images each of which are assigned the number for identifying and the angle of the representative line. The following is the process for the searching.

1. Input a query image
2. Extract the representative line from the query
3. Compute all distances of angle of representative line between the query image and every image in the DB
4. Output the identity number of each image of the DB retrieved for the query in increasing order on the distance

The performance of the search system are evaluated by comparing two different ways of computing distance that one is weighted related to the angle of the representative line, and the other is not. The followings are the formulas for computing the precision and recall used for evaluating.

$$\begin{aligned} A_k^j &= \textstyle\sum_{i=0}^{k-1} V_i(\text{detections})\\ B_k^j &= \textstyle\sum_{i=0}^{k-1} 1.0 - V_i(\text{falses})\\ C_k^j &= \textstyle\sum_{i=k}^{N-1} V_i(\text{misses}) \end{aligned} \quad (3)$$

$$\text{Recall}: R_k^j = \frac{A_k^j}{A_k^j + C_k^j}$$

$$\text{Precision}: P_k^j = \frac{A_k^j}{A_k^j + B_k^j}$$

j : the index of query image

k : the rank of the retrieval result

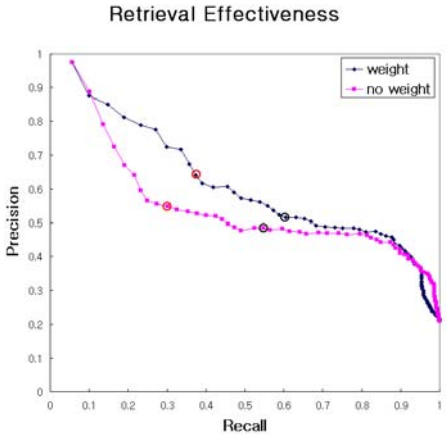
V_i : the subjective similarity of ith image

The V_i is the subjective similarity between the query image and the i^{th} image of the results. This value is computed by dividing the number of voting for the image *i* with given query image by the number of subject people. Thus, the value ranges from 0 to 1.0.

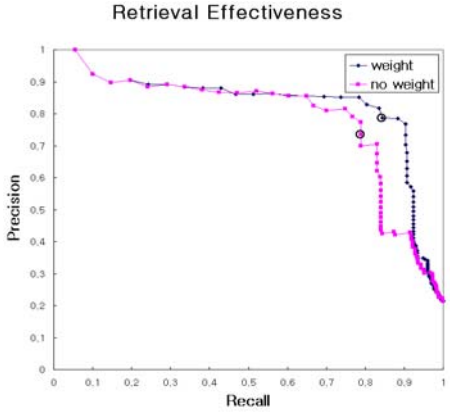
The Figure 4 shows the results of the experiments with each of the some query images in which the representative line's angle ranges variously. In the case that the angle of the representative line of a query is near vertical or horizontal, the result with the weight is better than the result without the weight. For the leftmost 10 samples, the result without the weight has 0.54 of recall and 0.30 of precision, and

the result with the weight has 0.64 of recall and 0.37 of precision.

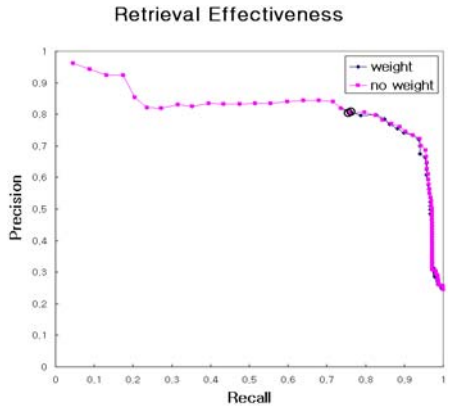
In the case that the angle of the representative line of a query is near diagonal, although both results are similar for some of leftmost part of the samples, the result with weight is getting better than the result without weight as the number of samples increase In the case that the angle of the representative line of a query is vertical or horizontal, both results are almost same for the whole samples.



(a) The result about the query image which has the near vertical or horizontal angle of the representative line



(b) The result about the query image which has the near diagonal angle of the representative line



(c) The result about the query image which has the vertical or horizontal angle of the representative line

Figure 4. Average retrieval effectveness. The "o" marks the average precision P_k and recall R_k for the top k^{th} results (k = 10 if red, and k = 20 if black).

5. CONCLUSION

In this paper, we found the property of line that affects compositional similarity and the relation between the angle of the representative line of a query image and that of its retrieved images in the DB by analyzing the results of the experiments. In addition, we suggested the method for measuring compositional similarity, and designed and implemented the search system in which the method is applied. In order to verify the search system, we compared proposed scheme to simple scheme in the sense of precision and recall. Although the result is slightly changed according to the angle of the representative line of a query image, it shows reasonable performance in the most of case.

6. ACKNOWLEDGMENTS

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