Fuzzy Similarity Measure for Shape Retrieval

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Abstract

In the image database, features (colors, shapes, textures) of the query specification are compared with features of the image database to determine which images match correctly (similar) with the given features. The matching process is based on similarity measure between query image and images in database.
In this paper we propose a fuzzy similarity measure for shape described by Fourier Descriptors.

1. Introduction

Rapid advances in computers and communication technology are pushing the existing information processing tools to their limits. The past few years have seen an overwhelming accumulation of digital data such as images, video, and audio. The Internet is an excellent example of distributed databases containing several millions of images. Other examples of large image databases include satellite and medical imagery, where it is often hard to describe or to annotate the image content.

The database methodologies are concerned with efficient storage and record retrieval. A good database offers fast search coupled with the ability to handle a large variety of queries. Traditional database techniques have been adequate for many applications involving alphanumeric records, which could be ordered, indexed and searched, for matching patterns in a straightforward manner. However, in many scientific database applications, the information is non-alphanumerical by nature. In particular, the large-scale image databases emerge as the most challenging problem in the field of scientific databases. This is due, in part, to the huge volumes of data that need to be managed in typical applications (e.g., satellite images, medical images, etc.). Due to the low cost of scanners and storage devices, digital images are now playing an important role in depicting and disseminating pictorial information. Techniques that have been developed to deal with alphanumeric records are inadequate for image data. The information content of images is not explicit, and is not easily suitable to direct classification, indexing and retrieval.

Several systems have been developed recently to search through image databases using color, texture, and shape attributes [1][2][3][7].
These systems use color, texture and shape features for image queries. Using color to index and search images dates back to some of the early work of Swain and Ballard [4] on color histograms.

While texture analysis has a very rich history in image processing and vision, the multiplication of image databases is perhaps one of the first large-scale applications demonstrating the use of texture.
Shape is another low-level attribute that can be used to represent local image information. However, it is not as widespread as color and texture, as it requires the extraction of region/object boundaries, which is a difficult problem.

In the retrieval process, features (colors, shapes, textures) [1, 2, 3] of the query specification are compared with features of the image database to determine which images match correctly (similar) with the given features. The matching process is based on similarity measure between query image and images in database.

There are several similarity measures that are proposed and used for varied purposes. These measures are based both on crisp [4] as well as fuzzy logic [5]. In some applications such as image databases, measures based on fuzzy logic would appear to be naturally better suited [6].

In this paper we propose a fuzzy similarity measure for shape described by Fourier Descriptors.

2. Fourier-based Shape Description

In the area of shape analysis and classification, several shape feature representation schemes based on auto-regressive (AR) models and Fourier Descriptors [8] [9] of contours have been proposed. Recently, an experimental comparison of shape classification methods on these two principles has been carried out, which indicate that Fourier-based methods provide better performance than AR-based approaches, especially for noisy images [10]. For this reason, we use the Fourier-based shape descriptions in our image retrieval system.

Let us consider contour γ_1 with Fourier Descriptors $C_k(\gamma_1)$. The magnitude of these coefficients altogether form a useful set of descriptors, since it has the profitable property of invariance with respect to basic similarity transformations, such as translation and rotation. Hence, the same shape appearing at a variety of positions and orientations, and possessing different starting points, would all yield the same set of descriptors.
So we consider the vector defined by:

$$I = \left[\frac{|C_{-N/2}(\gamma)|}{|C_1(\gamma)|}, \ldots\ldots, \frac{|C_{-1}(\gamma)|}{|C_1(\gamma)|}, \frac{|C_2(\gamma)|}{|C_1(\gamma)|} \ldots\ldots, \frac{|C_{N/2}(\gamma)|}{|C_1(\gamma)|} \right]$$

3. Similarity function.

For retrieval based on similarity of the two features, a distance between the two can be defined as a match measure. The distance measure can be used to retrieve images in the database. However, This measure can not reflect how closely a database picture is similar to a query picture.

In this section, we present a particularly intuitive similarity function **S,** which reflect the degree of resemblance between the query and target images.

Let us consider the invariant description $I = [I_1, \ldots\ldots, I_i, \ldots.., I_N]$ of contour defined in section 1. The proposed similarity function is given by:

$$S(Q_i, M_i) = \begin{cases} 1 - \dfrac{d_{Q_i,M_i}}{Max(Q_i, M_i)} & \text{If } Q_i \text{ and } M_i \neq 0 \\ 1 - \dfrac{d_{Q_i,M_i}}{M} & \text{If } Q_i \text{ or } M_i = 0 \\ 1 & \text{If } Q_i \text{ and } M_i = 0 \end{cases}$$

where d_{Q_i,M_i} is the distance between the query image index component Q_i and the model image index component M_i. N is the maximum component value in the vector corresponding to the non zero value.

The similarity function satisfies the following properties:

- S is reflexive ($S(I_i, I_i) = 1$), a value is totally similar to itself, $I_i \in [0, 1]$.
- S is symmetric ($S(Q_i, M_i) = S(M_i, Q_i)$).
- A more robust definition of transitivity holds:

$$\forall Q_i, M_i, N_i \quad S(Q_i, N_i) \geq Min\{S(Q_i, M_i), S(M_i, N_i)\}$$

4. Retrieval procedure

The images are represented by an *N*-dimensional feature vectors. The similarity measure is calculated for each component of the features vectors. Hence, for each pair of images, we have N similarity measures. The global similarity measure is obtained by two methods:

The first one, uses a fuzzy If-Then rule as [5] :

If { (Q_1 is close to M_1) and (Q_2 is close to M_2). . .and (Q_N is close to M_N) } then Q is similar to M.
In this case, the global similarity measure is given by:
$S_g(Q, M) = Min\{ S(Q_1, M_1), S(Q_2, M_2), \ldots, S(Q_N, M_N)\}$.

The second one, consider each similarity measure obtained between two components as an opinion. The global similarity measure, consist in choosing a global opinion from the all. In fuzzy logic, this requires an aggregation operator. The aggregation operator, which was investigated in this work, is the average of the N similarity measures [6].

$$S_g = \frac{\sum_{i=0}^{N-1} S(b_i^1, b_i^2)}{N}$$

To show the effectiveness of the proposed similarity function, we propose an experiment, which computes the Fourier coefficients of an original image and different images obtained by modifying this in gradual steps. Hence the obtained sequence shows closer resemblance (monotonically decreasing) to the original image. The similarity measures between the original image and each one of the sequence are given in the figure 1. On this example figure 1, distances it based on average aggregation operator gives a measure of closer similarity to the intuitive notion of a distance between forms. It is this distance that we will use thereafter.

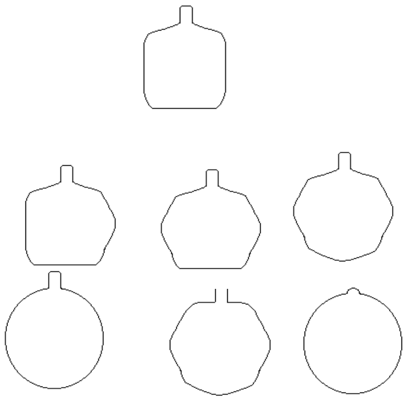
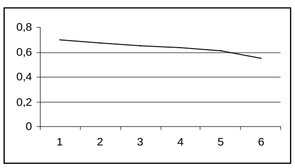
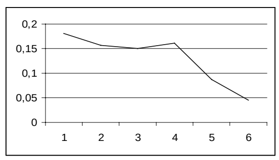


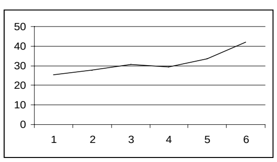
Figure 1:Query image 1), 2), 3), 4), 5), 6) Modified images in gradual steps



(1)



(2)



(3)

Figure 2: Similarity measures of Fourier coefficients (1) Average aggregation operator, (2) IF Then rule, (3) Distance measures

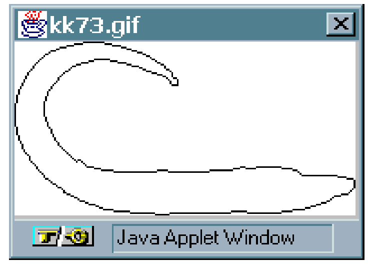
5. Experiment Results

We use the Vision, Speech, and Signal Processing Surrey University database, which contains about 1100 images of marine creatures. Each image shows one distinct species on a uniform background. Every image is processed in order to recover the boundary contour, which is then represented by Fourier descriptors.

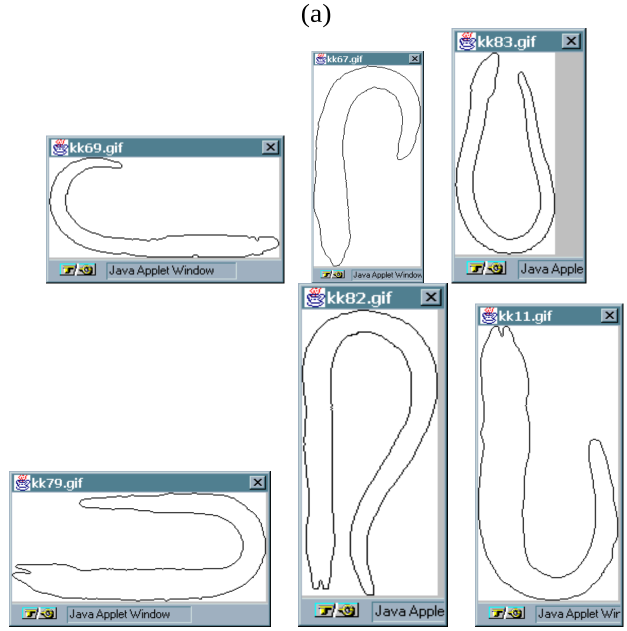
An example of query image is shown in Figure 3a, 4a. The retrieval of images with the highest similarity ranks is shown in Figure 3b, 4b.

The ability to perceive as similar, objects that have undergone a great variation in shape is typical of human beings. By robustness we intend the ability of the system to retrieve objects of the same kind as query image, irrespective of shape variations of the database instances.

As we can see in Figure 3 and 4, the obtained results show that the retrieval system is robust to these variations. Moreover, the retrieved images are in different positions and orientations.

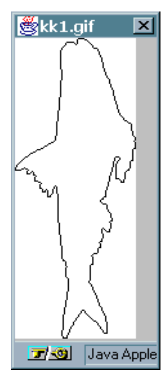


(a)

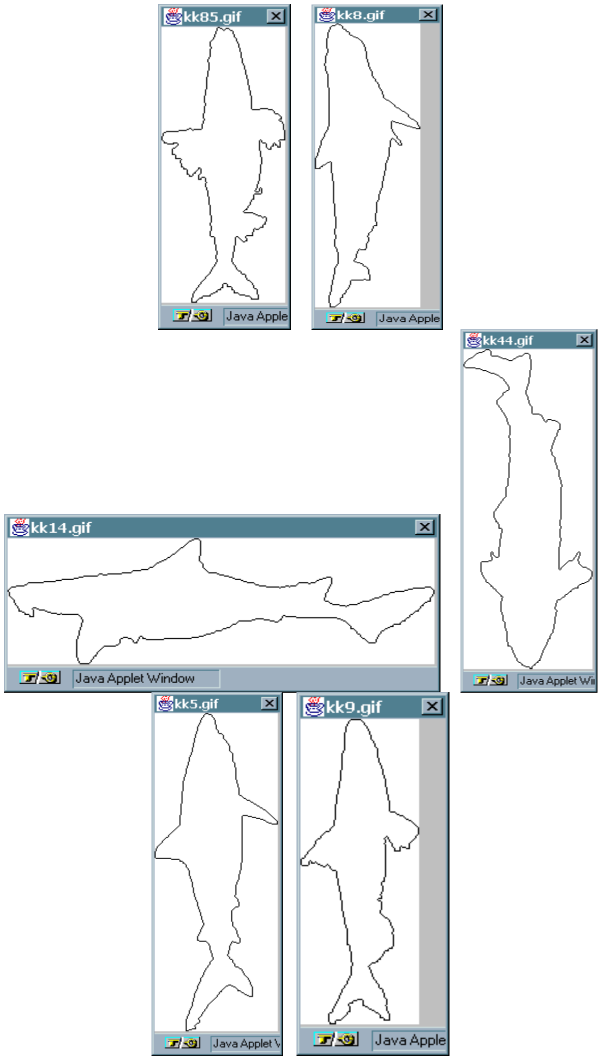


(b)

Figure 3: (a) Target Image (b) Six first's matching images



(a)



(b)

Figure 4: (a) Target Image (b) Six first's matching images

6. Conclusion

Visual information retrieval system is useful only if it can retrieve acceptable matches in real time. This requires the choice of a suitable set of image features and a feature distance measure that can be computed in real time.

In this paper we have proposed a fuzzy similarity measure for shape described by Fourier Descriptors. The obtained results show the efficiency of this distance.

7. Bibliography

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