Content Based Image Retrieval using RIP Model

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Abstract – Effective and efficient retrieval of similar shapes from large image databases is still a challenging problem. In spite of the high relevance that shape information can have in describing image contents, retrieving the images from the database with an image is a challenging task. Many of them proposed many theories to accomplish the task but failed to accomplish it, as the language of the image is quite difficult to understand for the machine. In this paper we are proposing a novel approach to retrieve images based on the shape features using Phase-based approach, called RIP (Retrieving the Images with Phase), with which we are going to increase the precision and recall.

Keywords – Shape Matching, Shape Extraction, Image Retrieval, RIP Model, Phase Oriented Image Retrieval, CBIR.

I. INTRODUCTION

Visual information plays an important role in our society. It will play an increasingly pervasive role in our lives, and there will be a growing need to have these sources processed further. The pictures or images are used in many application areas like architectural and engineering design, fashion, journalism, advertising, entertainment, medicine etc. It provides the necessary opportunity for us to use the abundance of images. However, the knowledge will be useless if one can't find it. This has motivated growing research interest on efficient and effective methods enabling the retrieval of images on the basis of their content from large databases. With respect to other features like color and texture, shape is much more effective in semantically characterizing the content of an image [1], [2], [3], [4].As we know, visual features of the images provide a description of their content. Content-based image retrieval (CBIR) emerged as a promising mean for retrieving images and browsing large images databases. CBIR has been a topic of intensive research in recent years. It is the process of retrieving images from a collection based on automatically extracted features.

In general, shape descriptor is some set of numbers that are produced to describe a given shape feature. A descriptor attempts to quantify shape in ways that agree with human intuition (or task-specific requirements). Good retrieval accuracy requires a shape descriptor to be able to effectively find perceptually similar shapes from a database. Usually, the descriptors are in the form of a vector. Shape descriptors should meet the following requirements:

- The descriptors should be as complete as possible to represent the content of the information items.
- The descriptors should be represented and stored compactly. The size of descriptor vector must not be too large.
- The computation of distance between descriptors should be simple; otherwise the execution time would be too long.
- Shape feature extraction and representation plays an important role in the following categories of applications:
  - Shape retrieval: Searching for all shapes in a typically large database of shapes that are similar to a query shape. Usually all shapes within a given distance from the query are determined or the first few shapes that have the smallest distance.
  - Shape recognition and classification: Determining whether a given shape matches a model sufficiently or which of representative class is the most similar.
  - Shape alignment and registration: Transforming or translating one shape so that it best matches another shape, in whole or in part.
  - Shape approximation and simplification: Constructing a shape of fewer elements (points, segments, triangles, etc.), that is still similar to the original.

However, properly extracting and representing shape information are still challenging tasks. In particular, even when accurate object boundaries are obtainable (this is the case when some domain knowledge is available or when images represent simple objects), the problem of representing them so as to allow the implementation of efficient and effective matching and retrieval methods is still not solved in a satisfactory way. The scenario is further complicated when invariance, with respect to a number of possible transformations, such as scaling, shifting, and rotation are required.

Effective and efficient retrieval of images based on their shape content calls for a set of basic often contrasting requirements: Compactness and simplicity of shape descriptors are necessary for minimizing the storage overhead and the extraction time; for an effective retrieval, the shape descriptors should be robust to noise and invariant to transformations (namely, translation, scaling, and rotation); Finally, in order to avoid a sequential scan of the whole (large) database, shape descriptors should be indexable, e.g., by using metric trees, like the M-tree [5], that are already profitably applied in several other image and multimedia applications [4], [6].
In this paper, we propose a novel approach for shape retrieval using RIP model in CBIR, which extends previous methods with two innovative characteristics: 1) The preservation of phase information and 2) The use of the Dynamic Time Warping distance to compare the shape descriptors. In terms of classical precision/recall measures, RIP can achieve good performance in the retrieval process. In next coming sections we discussed related work, Proposed System, Experimental Setup and Conclusion respectively.

II. RELATED WORK

The ability to retrieve by shape is perhaps the most obvious requirement at the primitive level. Unlike texture, shape is a fairly well-defined concept – and there is considerable evidence that natural objects are primarily recognized by their shape [7]. A number of feature characteristics of object shape (but independent of size or orientation) are computed for every object identified within each stored image. Queries are then answered by computing the same set of features for the query image, and retrieving those stored images whose features most closely match those of the query. Two main types of shape feature are commonly used – global features such as aspect ratio, circularity and moment invariants [8] and local features such as sets of consecutive boundary segments [9]. Alternative methods proposed for shape matching have included elastic deformation of templates, comparison of directional histograms of edges extracted from the image [10, 11], and shocks, skeletal representations of object shape that can be compared using graph matching techniques [12,13]. Queries to shape retrieval systems are formulated either by identifying an example image to act as the query, or as a user-drawn sketch [14, 15].

Shape matching of three-dimensional objects is a more challenging task – particularly where only a single 2-D view of the object in question is available. While no general solution to this problem is possible, some useful inroads have been made into the problem of identifying at least some instances of a given object from different viewpoints. One approach has been to build up a set of plausible 3-D models from the available 2-D image, and match them with other models in the database [16]. Another is to generate a series of alternative 2-D views of each database object, each of which is matched with the query image [17]. Related research issues in this area include defining 3-D shape similarity measures, and providing a means for users to formulate 3-D shape queries [18].

Many shape description and similarity measurement techniques have been developed in the past. A number of new techniques have been proposed in recent years. There are 3 main different classification methods as follows:

1. Contour-based methods and region-based methods [19]. This is the most common and general classification and it is proposed by MPEG-7. It is based on the use of shape boundary points as opposed to shape interior points. Under each class, different methods are further divided into structural approaches and global approaches. This sub-class is based on whether the shape is represented as a whole or represented by segments/sections (primitives).
2. Space domain and transform domain. Methods in space domain match shapes on point (or point feature) basis, while feature domain techniques match shapes on feature (vector) basis.
3. Information preserving (IP) and non-information preserving (NIP). IP methods allow an accurate reconstruction of a shape from its descriptor, while NIP methods are only capable of partial ambiguous reconstruction. For object recognition purpose, IP is not a requirement.

Among the different approaches that are available for the representation of shape information, those based on the Discrete Fourier Transform (DFT) describe the outside contour by means of a limited number of coefficients in the frequency domain. It is well recognized nowadays that Fourier-based approaches are able to provide all of the above-mentioned requirements, obtaining good effectiveness levels along with efficiency in retrieval and index ability. It has to be observed that, since DFT coefficients also carry information about the size, the orientation, and the position of the object, they have to be properly normalized in order to achieve invariance with respect to the desired transformations.

The fig.1 shows the hierarchy of the classification of shape feature extraction approaches.

Fig.1. Review of shape classification methods
III. SHAPE PARAMETERS

Basically, shape-based image retrieval consists of the measuring of similarity between shapes represented by their features. Some simple geometric features can be used to describe shapes. Usually, the simple geometric features can only discriminate shapes with large differences; therefore, they are usually used as filters to eliminate false hits or combined with other shape descriptors to discriminate shapes. They are not suitable to be stand alone shape descriptors. A shape can be described by different aspects. These shape parameters are Center of gravity, Axis of least inertia, Digital bending energy, Eccentricity, Circularity ratio, Rectangularity, Convexity, Solidity, Euler number, Profiles, Hole area ratio.

Table 1: Description of Shape Parameters

<table>
<thead>
<tr>
<th>Shape Parameter</th>
<th>Description and Formulae</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Center of gravity</strong></td>
<td>The center of gravity is also called centroid, its centroid ((g_x, g_y)) is (g_x = \frac{1}{N} \sum_{i=1}^{N} x_i) (g_y = \frac{1}{N} \sum_{i=1}^{N} y_i)</td>
</tr>
<tr>
<td><strong>Axis of least inertia</strong></td>
<td>The axis of least inertia is unique to the shape. Let (\alpha) be the angle between the axis of least inertia and the x-axis. The inertia is given by (I = \frac{1}{2} (a + c) - \frac{1}{2} (a - c) \cos(2\alpha) - \frac{1}{2} \sin(2\alpha))</td>
</tr>
<tr>
<td><strong>Digital bending energy</strong></td>
<td>Average bending energy (BE) is defined by (BE = \frac{1}{N} \sum_{k=0}^{K} (k \alpha)^2)</td>
</tr>
<tr>
<td><strong>Eccentricity</strong></td>
<td>Eccentricity is the measure of aspect ratio. It is the ratio of the length of major axis to the length of minor axis. It can be calculated by principal axes method or minimum bounding rectangle method.</td>
</tr>
<tr>
<td><strong>Circularity ratio</strong></td>
<td>Circularity ratio represents how a shape is similar to a circle. There are 3 definitions 1. The ratio of the area of a shape to the area of a circle (C_1 = \frac{A_s}{A_c}) 2. The ratio of the area of a shape to the shape’s perimeter square (C_2 = \frac{A_s}{P^2}) 3. Circle variance (C_{cv} = \frac{\sigma_B}{\mu_B})</td>
</tr>
<tr>
<td><strong>Elliptic variance</strong></td>
<td>A shape of an ellipse that has an equal covariance matrix (E_{oo} = \frac{\sigma_B}{\mu_B})</td>
</tr>
<tr>
<td><strong>Rectangularity</strong></td>
<td>Rectangularity represents how rectangular a shape is (\text{Rectangularity} = \frac{A_s}{A_B})</td>
</tr>
<tr>
<td><strong>Convexity</strong></td>
<td>Convexity is defined as the ratio of perimeters of the convex hull (O_{\text{convex hull}}) over that of the original contour (O): (\text{Convexity} = \frac{P_{\text{convex hull}}}{P_O})</td>
</tr>
</tbody>
</table>

| Solvity | Solvity describes the extent to which the shape is convex or concave and it is defined by: \(\text{Solvity} = \frac{A_s}{A_h}\) |
| **Euler number** | Euler number describes the relation between the number of contiguous parts and the number of holes on a shape. Let \(S\) be the number of contiguous parts and \(N\) be the number of holes on a shape. Then the Euler number is: \(\text{EUL} = S - N\) |
| **Profiles** | The profiles are the projection of the shape to x-axis and y-axis on Cartesian coordinate system. \(Pro_x(i) = \sum_{j=0}^{image} f(i,j)\) \(Pro_y(j) = \sum_{i=0}^{image} f(i,j)\) |
| **Hole area ratio** | Hole area ratio \(HAR\) is defined as \(\text{HAR} = \frac{A_h}{A_o}\) |

IV. PROPOSED SYSTEM

Fig. 2 shows the general scheme of the proposed system to extract shape feature from an Image in Content based Image Retrieval (CBIR) system using phases. The basic idea of this system is to extract shape features efficiently from image in different phases. The following sections are discussed about various steps involved in the proposed system.

![Fig.2. Architecture of the Proposed System](image)

V. SHAPE EXTRACTION

We used canny filter to change RGB image to a binary image and canny edge detection technique to determine the shape pixel by pixel for the accurate extraction. The
results of canny filter are shown in the fig 3(a) and canny edge detector in fig 3(b).

![Fig.3. (a) Results of Canny filter](image)

![Fig.3 (b) Results of Canny edge detection](image)

VI. WHY CANNY?

We have many edge detection techniques, techniques such as Sobel operator, Robert’s cross operator, Prewitt’s operator, Canny edge detection algorithm etc. are most popular edge detection techniques. The reason why we choose canny can be easily understood from the fig 4(a).

The input image to the techniques is in fig 4(b) Canny is detecting the shape accurately when compared to others. It is adaptable to various environments.

Euclidean distance is used to measure the similarity measure of the query image and the images in the feature database. Using the Canny and the Euclidean the results obtained are as shown in figure 5

If we apply our RIP approach before similarity measure we are able to increase the precision and recall

![Fig.4. (a) Comparison of various Edge detection techniques.](image)

![Fig.4(b): Input given to the different edge detecting techniques](image)

![Fig.5. No-Phase Euclidean measure; R is relevant image; Q is query image](image)

VII. RETRIEVING THE IMAGES WITH PHASE (RIP)

Retrieving the Image with Phase is a technique where we can identify the rotated images with the same or relevant semantics. In this technique we rotate the image at the regular intervals of \(\frac{\pi}{4}\) and then compare with feature database to retrieve more number of relevant images. Consider an image shown in fig 6(a) as the input image to the Rotating algorithm we will be able to produce eight semantically same rotated images as we are rotating them at the regular interval of \(\frac{\pi}{4}\) as shown in the fig 6(b)
Now the rotated images are given to the Euclidean algorithm to measure the similarity between the eight output images obtained from the rotating algorithm with the feature database and then the images are retrieved. Now the retrieved images will have more relevancies when compared to the previous approach. Using the RIP the results are obtained as shown in fig 6(c).

VIII. EXPERIMENTAL SETUP

We implemented the RIP method in JAVA under Windows XP. For performance evaluation, we used the FISHES data set provided by [20], consisting of 1,100 text files containing the coordinates of boundary points of an object with each object representing a marine animal. The length of each boundary varied from 256 to 1,653 points. We manually classified each image based on 10 semantic categories ("Seahorses" (5 images), "Seamoths" (6), "Sharks" (58), "Soles" (52), "Tonguefishes" (19), "Crustaceans" (4), "Eels" (26), "UEels" (25), "Pipefishes" (16), and "Rays" (41)). Images not belonging to any category were assigned to a default class (848).

Table 2 shows some images in the data set, along with their category. The query workload used in our experiments consists of 30 query images chosen from the 10 semantic categories. For evaluation purposes, any image in the same category of the query is considered relevant to that query, whereas all other database images are considered irrelevant. To measure the retrieval effectiveness, we considered classical precision (P) and recall (R) metrics averaged over the set of processed queries.

<table>
<thead>
<tr>
<th>Image</th>
<th>Category</th>
<th>Card.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rays</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Seahorses</td>
<td>5</td>
<td></td>
</tr>
<tr>
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<tr>
<td>Soles</td>
<td>32</td>
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