Radial-Distance Based Shape Descriptor for Image Retrieval

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Abstract— Shape analysis is used in many application fields including emerging virtual environments or 3D model market, security applications, medical imaging and many more. A Shape descriptor (or Signature) is the simplified representation of images. These shape descriptors carry important image information to store and makes easy the comparing of different shapes. The proposed shape descriptor is based on radial-distances. The type of shape descriptor used here is contour-based shape descriptor. Distance from center of bounding box encompassing the edge image to farthest point on the edge is calculated. A circle is drawn using the distance mentioned above as radius. The ratio of Euclidean distances of an edge pixel and the radius is considered as a feature. A set of such ratios for all the edge pixels forms a shape descriptor. The descriptor is divided into segments so as to avoid global distribution. A rotational matching scheme ensures invariance to rotation. As the computation of feature set is compact, implementation of this method results in quick retrieval of images invariant to scaling, translation and rotation.

Keywords- *Centroid, Contour, Euclidean-Distance Radial-distance based shape descriptor.*

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I. INTRODUCTION

Rapid growth in multimedia applications has led to a growing interest in retrieval of images from remote databases or from large collections. There is a demand for searching tools which are effective in identifying of images from large databases. One of the visual features which is important to describe contents of image is shape. Some of the parameters called shape parameters that describes the shape are area, bounding rectangle, compactness, roundness, elongation, convexity, axis of least inertia, Circularity ratios, digital binding energy, elliptic variance, Euler number and whole area ratio.

Shape similarity can be measured by measuring similarity between features. The shape features must exhibit some of the properties that are essential for efficient shape features. Shape must be identifiable and properties such as statistically independent, noise resistance, reliable, affine invariance, translation scaling and rotation invariance must be present.

Shape descriptors describe given shape and are generally some set of numbers. Shape descriptors must not be in large size and therefore must be stored compactly and must fulfill the requirement of shape approximation and simplification to obtain good accuracy results.

Classification of shape representation and description techniques can be done in and as two methods. They are Contour-based methods and Region-based methods. The proposed shape descriptor is Contour-based. The contour-based shape descriptor extracts only boundary information. Only the outline or the boundary of the given image is the part of concentration and the rest of the inside region is not considered. Boundary-based method is again differentiated as two other methods called global approaches and structural approaches. In Global approaches the image outline is considered for feature extraction. In Structural approaches the contour can be divided into blocks or quadrants. This segmentation of contour makes structural approach localized.

II. CONTOUR-BASED SHAPE DESCRIPTORS

This section includes some existing boundary-based shape descriptors based on the classification as mentioned in the previous section. The figure below shows some of the shape descriptors coming under Global and Structural approaches of contour-based methods.

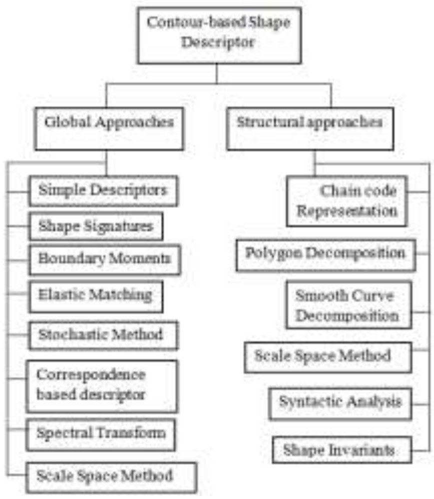


Fig 2.1: Global and structural shape descriptors.

Global approaches

Amongst the many global approaches for contour-based shape descriptor, few are explained in this section.

Simple descriptors

Some of the simple shape descriptors are:

a) *Circularity ratio*:

Defined as C1=As/Ac (Area of Shape/Area of Circle) where circle has the same perimeter. It also has two other definitions: $C2=As/p^2$ (Perimeter of Shape). Here C2 is calculated as Area to the squared perimeter.

b) *Eccentricity*:

Eccentricity which is the measure of aspect ratio is calculated by minimum bounding box or by principal axes method. Two line segments that perpendicularly cross each other through the centroid with zero cross relation is called principal axes.

c) *Rectangularity:*

It is defined as $R= A_S/A_R$ (A_S: Area of shape and A_R is the area of minimum bounding box).

d) Average Binding Energy:

With minimum binding energy [1], one can prove that the circle is the shape. Average binding energy is defined as

$$BE= 1\frac{1}{N}\sum_{s=0}^{N-1} K(s)^2 \quad \text{....... 2.1}$$

Where k(s) is parameterized shape curvature.

Structural Approaches

Scale Space Approaches

In [2] Tsotsos applied a matching technique called model-by-model. This method saves computation while matching and provide robustness. It maintains local information regarding shape and is also fast, compact and reliable. The nature curvature scale space equation which is parameterized is given as:

$$\tau(\mu) = (x(\mu), y(\mu)) \quad \text{....... 2.2}$$

This approach helps in planar curve representation as it is multi-scale representation based.

Smooth Curve Decomposition

This method segments the image into tokens first. Orientation and minimum curvature is the feature for tokens. It is invariant to rotation because it is based on curve orientation feature. For each shape, the count of tokens is considered for evaluation of matching performance.

III. PROPOSED SHAPE SIGNATURE

The proposed shape descriptor takes the radial distance as feature computation for shape matching. This method is a contour based shape descriptor which considers only the boundary pixels of the image as feature. Dataset used here is MPEG 7. The steps involved in this method are as follows

1) Image Reading

The input images are accessed from the dataset. The function imread() is used for this purpose. The path of the folder where the dataset is stored is specified in the function while reading along with the image name. Read images are converted into binary format. This makes the computation easy. Then the pixels that form the outline of the image are found out. Once the boundary pixels are obtained, they are stored separately for further computations**.**

2) Calculation of Radial Distance

A tight bounding box is drawn for the image as shown in Fig 3.1 after contour points are obtained. The centroid is calculated which gives the coordinates $C(X_{c,}Y_c)$. Radius R that is the maximum distance from centroid to the farthest edge point on the image is calculated. Then a circle with radius R and center of tight system bounding box as C is fit around the image shown in Fig 3.2. The coordinate points of circle are extracted.

Fig 3.1 : Binary image with tight bounding box

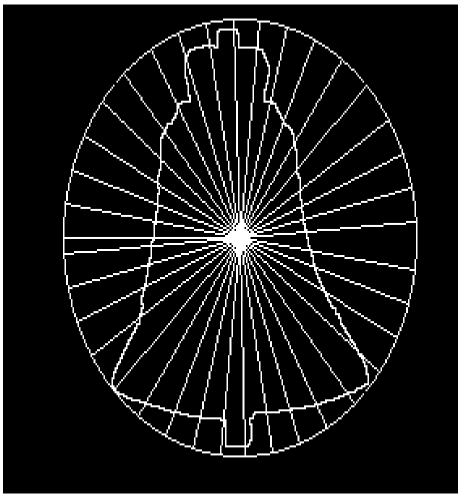


Fig 3.2 : Circle fitting and binning

3) *Image Segmentation*

The image is divided into n equal number of segments after drawing the circle. For each segment, the distance from centroid to pixels lying in that segment is calculated. The ratio of distance calculated over the radius is found out. This ratio is considered as the feature set for this method.

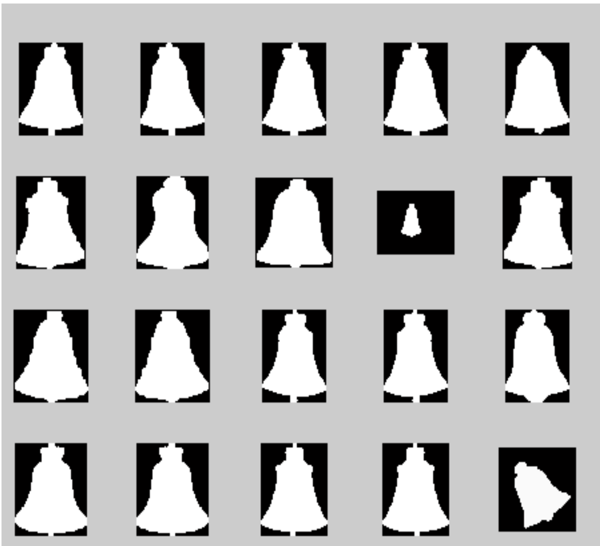
4) *Shape Matching*

The distance ratio is plotted on the histogram as the feature. Normalized Histograms for each of the segment for an image is computed. For matching, the minimum distance between shapes after rotational match in both the directions, is obtained.

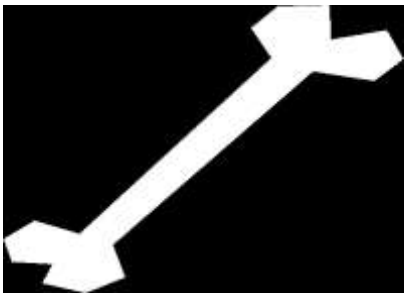
IV. RESULTS

Dataset consists of 70 classes, each class having 20 images. The radial-distance method is executed for all the images in the dataset and the feature set for each image is calculated and stored. A randomly chosen image can be taken as query image and shape matching occurs between the query image and all other images in the dataset one by one. The results obtained are as shown below.

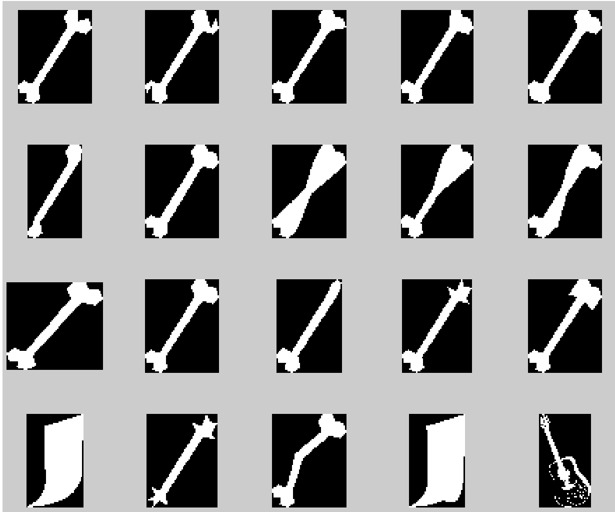
Query Image



Output



Query image



Output

The evaluated performance of the shape signature is shown in the below table. The table shows the top results gained.

TABLE1: GROUP PERFORMANCE OF SHAPE SIGNATURE

GROUP PERFORMANCE IN PERCENTAGE (%)

Class	Top 10	Top 15	Top 20
'CAR'	100	100	100
'CATTLE'	100	66.6	50
'HAT'	100	100	100
'JAR'	100	86.6	80
'LIZARD'	60	46.66	35
'MISK'	100	93.3	80
'SHOE'	100	93.3	90
'STEF'	100	100	100
'TURTLE'	100	86.6	70
'WATCH'	100	100	100

CONCLUSION

The Radial-distance based shape descriptor considers only the edge pixels of image for evaluation. The radial distance from centroid is calculated which is taken as feature set for all images of MPEG 7 dataset. This method is efficient and yields good top retrieval of images and with features being compact the retrieval rate is also good. The shape descriptor also provides invariance towards mirroring effect, translation, rotation and scaling.

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