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Survey on Shape Description and Recognition Techniques

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ABSTRACT

The images have to be described by certain features. The shape is an important visual feature in understanding an image, that remains stable in spite of changes in an object's illumination, color, and texture. So shape features have been applied in object recognition tasks. There are many shape description and recognition techniques in the literature. This survey paper provides an overview of description and recognition techniques and examines implementation procedures for each technique and its advantages and disadvantages. Finally, identify some techniques for image retrieval according to standard principles.

Keywords: Shape; Image retrieval; Shape descriptor; Shape recognition

I. INTRODUCTION

In the field of computer vision, recognition of objects in an image is one of the essential problems. The object recognition needs a powerful representation, extracting the important features and to find a similar object from remotely distributed databases. In most applications, the object analysis can be reduced to the analysis of only shapes, as the shape of the object contains perceptual information used to describe both object boundary as well as the content. The shape is an important visual feature used to describe image content. However, shape recognition and description is a difficult task because of 3-D real-world object is projected onto a 2-D image plane, one dimension of object information is lost. This resulted as extracted shape from the image only partially represented as a projected object. To make the problem even more complex, the shape is often corrupted with noise, defects, and occlusion.

Shape representation generally focuses on effective and perceptually important shape descriptors based on shape boundary information. Various features such as shape signatures, shape invariants, curvature, shape context. Shape features are often evaluated by how accurately to retrieve similar shapes from a designated database. Better retrieval accuracy requires efficiently find perceptually similar shapes from a database. The perceptually similar shape means rotated, translated, affine transform and descriptor should find noise affected shapes, distorted shapes which are tolerated by human beings comparing shapes. It is known as robustness requirement. A desirable shape descriptor should be independent for application rather than performing well in a certain type of shape and low computation complexity.

Image Retrieval is one of the fastest-growing research areas. Image Retrieval classified into three types. They are Content-Based image retrieval (CBIR), text-based image retrieval (TBIR) and semantic-based image retrieval. Mainly focus on CBIR. Content-Based Image Retrieval systems have been used for the searching of relevant images in various research areas. The previously used method is text-based queries are not as efficient and effective as feature-based methods. The primitive features such as color, shape, structure, texture, etc can be used to extract the similarities between the images already stored in a database and a query by the user. Recognition is the process of identifying and detecting an object and it is used in many applications like systems for toll booth monitoring, and security surveillance. Different types of recognition, mainly pattern recognition, object recognition, shape recognition. In object recognition technique there are different types of techniques are used like template matching, color-based, shape-based. Most commonly based on shape features, the shape is an important feature in understanding an image that remains stable in spite of advances in an object's illumination, color, and texture. Due to these shape features have been widely applied in an object recognition task.

II. IMPORTANT TERMINOLOGY

Properties of shape features such as:

- Identifiability: Shapes which are found perceptually similar by human have the same features but different from the others.
- Translation, rotation, and scale-invariance: The location, rotation and scaling changing of the shape must not affect the extracted features.
- Noise resistance: Features must be robust as possible against noise, whichever be the strength of the noise that affects the pattern
- Occultation resistance: Some parts of a shape are occulted by other objects, the feature of the remaining part must not change, in a given range, compared to the original shape,
- Statistical independence: Two features must be statistically independent. It represents the compactness of the representation.
- Reliability: It deals with the same pattern, the extracted features must remain the same.

Shape descriptors are produced to describe a given shape feature. Good retrieval accuracy requires a shape descriptor is effectively found perceptually similar shapes from a database. Usually, the descriptors are gathered under the form of a vector. Requirements of Shape descriptors:

- Completeness: Descriptors should be as complete as possible to represent the content of the information items.
- Simplicity: Computation of distance between descriptors should be simple; otherwise the execution time would be too long.
- Accessibility: To compute a shape descriptor in terms of memory requirements and computation time.
- Uniqueness: It indicates whether a one-to-one mapping exists between shapes and shape descriptors.
- Stability: It describes how stable a shape descriptor is to “small” changes in shape.

The goal of this paper is to gain an understanding of shape recognition and description techniques. These techniques have been developed in the past years. New techniques have been proposed in recent years. The feature extraction stage represents the content that is useful for shape matching. In this paper, we review and examine shape description and recognition techniques. In section II we discussed the classification of shape representation and description techniques are given. In section III we discussed contour-based shape representation techniques. Region-based shape representation techniques are discussed in section IV. In section V, we discussed the related research in shape recognition techniques and conclude in Section VI.

A. Classification of shape representation and description techniques

Shape representation and description techniques can be classified into two class methods: contour-based methods and region-based methods. The classification is based on whether shape features are extracted from the contour only are extracted from the whole shape region. Each class is subdivided into structural approaches and global approaches. It is based on whether the shape is represented as a whole or represented by segments. It can be further distinguished into the space domain and transform domain.

B. Contour-based shape representation and description techniques

Contour shape-based techniques only exploit shape boundary information. There are two types of different approaches for contour shape modeling: global and structural approaches. Global approaches do not divide the shape into sub-parts, usually, a feature vector derived from the integral boundary is used to describe the shape. Shape similarity measures usually a metric distance between the acquired feature vectors. Structural approaches break the shape boundary into sections, called primitives using a particular criterion.

C. Region-based shape representation and description techniques

In region-based techniques, all the pixels within a shape region are taken into account to obtain the shape representation, rather than only use boundary information as in contour-based methods. Region-based methods commonly use moment descriptors to describe shapes. Other region-based methods like shape matrix, convex hull, and media axis. It can also be divided into global and structural methods, depending on whether they separate shapes into subparts or not.

III. RELATED WORKS

In shape recognition, The effective recognition algorithm should be less complicated and more accurate. Curvature scale space (CSS), dynamic programming, shape context, Fourier descriptor, and wavelet descriptor are the example of these approaches. There are two approaches which are most commonly used for shape recognition structural approach because it uses primitive patterns to represent regular and irregular shapes. Any shape recognition with a structural approach has three steps are first extracting the structural feature of the shape then constructing a feature space for comparing and finally recognition.

In this section, we are presenting the research work of some prominent authors in the same field and explaining a short description of various techniques used for shape recognition.

Arbelaez et al. [1], proposed two fundamental problems are contour detection and image segmentation. State-of-the-art algorithms are used in both tasks. Combines contour detector and multiple local cues into a globalization framework, it is based on spectral clustering and segmentation algorithm. The segmentation algorithm consists of generic machinery for transforming into a hierarchical region tree, In this manner, reduce the problem of image segmentation of contour detection. Extensive experimental evaluation demonstrates that both contour detection and segmentation methods significantly outperform competing algorithms. The automatically generated hierarchical segmentation can be interactively refined by user-specified annotations.

R. Hong et al.[2], proposed an algorithm using color information in the HSV color space to obtain the pixel of the object which implements image segmentation, and implement edge detection to recognize the object by using this pixel. The experimental result shows that this algorithm can recognize the object exactly in the different illumination conditions and satisfy the requirement of the competition.

S. Belongie et al.[3], proposed a shape detection method using a feature called shape context. It is descriptive of the shape of the object, thus shape context describes all boundary points of shape for any single boundary point. Object recognition can be achieved by matching this feature with a priori knowledge of the shape context of the boundary points of the object.

W. Wang et al.[4], proposed by using a new descriptor and relaxation labeling technique, shape matching algorithm is developed. For each contour point, the descriptor captures the distribution of all points within the shape region along the vector perpendicular to that from the centroid to the point.

In addition to stable affine invariance, the descriptor is robust to noise since it makes use of all points in the shape region. Compared to the other four state-of-the-art contour-based shape matching algorithms, this algorithm is more robust and capable of shape matching under affine transformations and noise.

F. Mokhtarian et al.[5], proposed a method for retrieving shape similarity in large image databases which is robust to noise, scale and orientation changes of the objects. It represents the shapes of object boundary contours by using Curvature Scale Space (CSS). Then the matching algorithm has been designed to use global information, it is sensitive to major occlusion.

Y. Mingqiang et al.[6], proposed a new effective shape descriptor is chord context, for shape description image retrieval. It extracts attributes from both contours as well as regional information without the need for special landmarks or key-points. Chord context describes a frequency distribution of chord lengths with different orientations and this method is unaffected by translation, rotation, and scaling.

R.Wang et al.[7], proposed the values of a geometric characteristic of toe images based on the toe shape description method. Corner detection is carried out on the toe region, and the characteristic points which can describe the toe shape are confirmed by the edge of the image. Through finding characteristic points then distances to the center are stable and it can distinguish different toe shapes and the correlation among them.

H. Ling et al.[8], proposed the inner-distance is defined as the length of the shortest path between landmark points within the shape silhouette and build shape descriptors that are robust to articulation. It shows articulation insensitive and more effective at capturing part structures than the Euclidean distance. Three approaches are using the inner-distance, the first method combines the inner-distance and multidimensional scaling (MDS) to build articulation invariant signatures for articulated shapes. The next second method uses the inner-distance to build a new shape descriptor based on shape contexts and the third one extends the second one by considering the texture information along the shortest paths.

B. Wang et al. [9], proposed retrieval of leaf images by using shape description method. In this method multiscale arch height (MARCH), hierarchical arch height features at different chord spans are extracted from each contour point to provide a compact, multiscale shape descriptor, and leaf shape can be effectively captured. The experimental result achieves higher classification rate and retrieval accuracy.

E. Moomivand et al.[10], proposed a method in which the main property of shape (centroid) is considered as a basic point for recognition. Then, two structural properties such as distance and angles between the centroid and shape contour are calculated. At last, combining these two structural features and new Feature-Space is constructed. The proposed shape descriptor can measure periodical, and symmetry of shapes.

L. Nanni et al.[11], proposed a method based on the local phase quantization matrix description to improve the retrieval performance of traditional descriptors, such as the shape context, inner-distance shape context, and height function. For extracting features from the shape descriptors and improving the performance of the standard shape matches (ID/SC/HF).

M. Cui et al. [12], proposed the curvature of the curve and unsigned curvature integral to provide a curve descriptor, which samples the contour curve using the same curvature integral so that the sampling points are more concentrated on the curve, and the descriptor has a larger entropy value. Although the algorithm was a significant improvement for computational complexity and can match occluded objects, its descriptor is susceptible to noise.

Donggang Yu et al.[13], proposed novel and effective method of shape analysis and recognition based on skeleton and morphological structure. A series of pre-processing algorithms, smooth following, and liberalization are introduced, and a series of morphological structural points of image contour is extracted and merged.

J. Almazan et al.[14], proposed a novel feature extraction technique, that uses a non-rigid representation adaptable to the shape. This method employs a deformable grid based on the computation of geometrical centroids that follows a region partitioning algorithm. The result is a shape descriptor that adapts its illustration to the given shape and encodes the pixel density distribution.

Yang et al. [15], proposed a multiscale descriptor for shape matching and object recognition. the descriptor includes three types of invariants in multiple scales, to capture shape features from discriminative local, semi-global. Shape matching is employed by using a dynamic programming algorithm. The experiment results yield shape feature is invariant to translation, rotation, scaling and well tolerate partial occlusion.

X. Zhang et al.[16], proposed a multiscale ellipse descriptor (MED) method for shape description and matching. MED extracts the features of shape contour by measuring the spatial location relationship between sample points and topology structure information of the segmented multiscale zone. This method is effective and efficient.

X. Wang et al.[17], proposed mid-level modeling of shape representation and It focuses on designing low-level shape descriptors that are robust to rotation, scaling and deformation of shapes. Bag of Contour Fragments (BCF) is the new shape representation, inspired by classical Bag of Words (BoW) model. In BCF, a shape is decomposed into contour fragments and described by using a shape descriptor. Finally, a compact shape representation is built by pooling shape codes in the shape. The linear SVM classifier is used for shape classification. BCF achieves state-of-the-art performance on several well-known shape benchmarks.

M. R.Daliri et al. [18], Proposed two algorithms based on shape recognition. Each is map the contour of the shape to be recognized into a string of symbols. The first algorithm relies on supervised learning using string kernels. The second algorithm relies on weakly-supervised on the Procrustes analysis and on the edit distance used for computing the similarity between strings of symbols.

Jiexian Zeng et al. [1], Proposed a shape recognition algorithm based on the curvature bag of words model to solve that problem. First, object contour is obtained by using the discrete contour evolution algorithm. Next, based on the shape contour is decomposed into contour fragments. Then, this model is used to represent the contour fragments. Finally, a linear support vector machine used to classify the shape feature descriptors.

IV. CONCLUSION

These papers categorizes the various techniques in image recognition and description. The CBoW model algorithm effectively improves the recognition performance and robustness for nonrigid transformation and local deformation targets. These recognition and description techniques are based on many shape descriptors and can be used to evolve out a modified method of shape recognition in the world of constant evolution.

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