

A Brief Analysis of Shape Recognition

Qiao Zhaoyang

Computer science department

Baicheng Normal University

Baicheng, Jilin, China

qzhaoyang2013@163.com

Abstract—The shape recognition is an important research problem in the field of computer vision. It has been widely applied in the field of scientific research and engineering technology, such as object recognition, image retrieval based on content, character recognition, and medical diagnosis, etc. This paper introduces the key technology and the mainstream algorithms of shape recognition. At the same time it has also analyzed and summarized the advantages and disadvantages of various algorithms.

Keywords—computer vision; shape recognition; Hough transform; angular point

I. INTRODUCTION

Computer vision technology came out since 1960s and soon got rapid development and application. In the early 1980s, Marr proposed the theory of visual calculation. Based on this theory, the visual process was regarded as an information processing and was divided into three layers: computing theory, algorithms and data structures, and hardware experiment. Marr emphasized the layer of computing theory, which was ignored at that time. At this level the visual process was mainly stipulated for recovering the shape of three-dimensional objects and space position in the scene reflected by the image quantitatively.

Computer vision is a kind of science and technology, which studies to use computer to simulate biological explicit or macro vision function. The research goal is to make the computer have an ability to get the information of the surrounding environment through several images. This ability could not only make the machine percept the geometry information of objects in the environment, including its shape, position, gesture, movement, etc., but also describe, store, and recognize objects. Computer vision is related to multi-disciplinary subjects, such as image processing, pattern recognition, computer graphics, artificial intelligence, expert system and artificial neural network, and cognitive science. Computer vision as an important research field of computer science is widely applied in many fields, including remote sensing image analysis, character recognition, medical image processing, multimedia technology, image database, industrial test and military, etc. With the deepening of the interdisciplinary basic research and the rapid increase of computer performance, computer vision will be more widely used in more complex applications. Target recognition is the core part of computer vision.

II. TARGET RECOGNITION

Target recognition is the primary research topic in target tracking, robot visual navigation and positioning, direction of

intelligent monitoring and other related primary research subject. It is one of the most active research topics in the field of computer vision. In a broad sense, target recognition can be various, such as recognition of tactile, taste, hearing, visual and so on. In the military, electronic information is the main means, such as radar, sonar and satellite and so on. From the perspective of image understanding, image recognition can be divided into three levels: low, middle and high levels. Low-level processing usually refers to the processing of the original pixel level, which can be understood as "image processing" in a narrow sense. It is a general pretreatment for the middle-level processing, including image enhancement and restoration, filtering, segmentation, etc. The purpose of this level is to improve the quality of the image. Middle-level processing mainly describes and classifies the characters of the units segmented from the image based on low level processing. That is "pattern recognition".

At this level the target feature is extracted, such as area, and contour features, and then classified according to the theory of recognition. The purpose of this level is to describe and classify the target units. High-level processing refers to the image understanding based on the middle-level processing. It uses a computer to achieve the vision effect similar to human vision system. It is generally called the "computer vision". This level mainly explains the image. There is a mode reflecting scene with target features and a knowledge base serving to explain. The purpose of image understanding is to explain an image. It is inevitably involved in target recognition and illustrates the relationship among the targets in the image. Obviously the description and recognition of the target is one of the main contents, which is also the main content of middle-level processing. This level of processing is also the most crucial, which directly affects the final result of high-level computer vision.

After decades of development, the target recognition method has achieved remarkable results. At present, there are two main types: target recognition algorithm based on template matching and the algorithm based on the statistical pattern.

A. Recognition Algorithm Based on Traditional Template Matching

Template matching is a classic method of the earliest origin. Its principle is directly to make the difference between two corresponding pixel gray values of target area, and then to accumulate these differences and compare the accumulated value with the threshold to obtain the target recognition results. Its principle is simple, but the algorithm itself is very rough. The selection of threshold is also a difficult problem. Due to the diversity of the target, there are

no standardized criteria for the selection of threshold. In order to improve the accuracy of recognition, a lot of experiments are used to gain it. In addition, this algorithm has poor ability to resist noise interference and its adaptability and robustness are not high.

With the deepening of the research, people continue to have deep research in image data. Many scholars put forward the target recognition algorithms based on feature extraction. All kinds of characteristic function replace difference accumulation of the pixel gray level and are used widely in the field of target recognition. Hahnel had put forward the theory to extract the object's color features and texture features for recognition. Berg had put forward the theory to identify the object by the shape of the object matching. Csurka used a set of feature points to classify objects to recognize. Cao worded out a target recognition method based on corner feature matching. Ullman designed a target recognition method based on image block mechanism.

B. Recognition Algorithm Based on the Statistical Pattern

This kind of algorithm distinguishes the target from the type of sample. It requests a large number of samples to train the target classifier before target recognition. Only the trained target classifiers can classify the targets to recognize. Support vector machine (SVM) is one of the youngest but the most promising methods in statistical learning theory. It shows good learning performance in small sample classification. It is different from the traditional machine learning methods. It completes classification by mapping a binary classification problem into a high-dimensional feature space without complex algebra reasoning. It shows significant advantage in performance and speed. The research and development of Support vector machine (SVM) greatly promotes the progress of target identification algorithm. On the other hand it also puts forward new requirements, such as how to reduce the sample learning time and the number of required samples, how to choose kernel function and nuclear super parameter, and so on.

At present, although target recognition algorithm has achieved good results, but for the requirements of practical application, there still exist the following questions: Original Target Image with High Quality. High recognition accuracy requires high resolution of the original image. This puts forward higher requirements to the camera equipment and transmission equipment; It is not easy to get a clear target image. In practice, video acquisition devices are installed outdoors. Under the condition of bad weather, such as illumination change, rain and snow weather, cloudy and windy weather, and so on, it is easy to make image noise, which leads directly to vague image. It badly affects algorithm.; Due to the change of the scale, rotation, displacement and the influence of complex background, it requires scale rotating translational invariance for target characteristics and strong ability to resist noise. But in the actual research, it is difficult to find a way to meet the

requirements of the stability characteristics. It will be a difficult task for target recognition algorithm; Requirements for Real Time. In practice, most of the target recognition systems are real-time. This requires target recognition algorithm to have low computational complexity and high speed for hardware and software response; The Balance of the Recognition Speed and Accuracy. The accuracy of target recognition depends on feature extraction method. The improvement of accuracy accords with high complexity of the algorithm which leads to a fall in the processing speed of the machine. Therefore, how to balance between them is also a difficult problem worth studying deeply; The Promotion and Stability of Recognition Algorithm. Current target recognition algorithm of some achievements are mostly confined to a small scope, the algorithm does not have good generalization, such as robust face recognition algorithm may not be able to promote to the field of character recognition. Therefore, how to improve the USES of recognition algorithm and the stability is also a new research direction for target recognition algorithm; The Lack of a Unified Evaluation Criteria of Target Recognition Algorithm. Due to different applications of target recognition algorithm and the diversity of everything in the world, all possible targets are not exhaustive. So there are no unified normative criteria for each evaluation recognition system.

III. SHAPE RECOGNITION

When observing the surrounding environment, the first thing one notices is the object and the color of the object and its surrounding environment, texture, shape, and spatial relationships, etc. Shape is the basic intrinsic characteristics of scenery. Shape analysis and description of the algorithm is an essential part in the hierarchical structure of computer vision.

Shape is widely understood but difficult to define. It is an important parameter of human visual perception, recognition and understanding. Shape can be thought of as the object of a kind of external visual overall sense. It is a kind of external object description. In the image, the shape of the object can be used to represent the outline of the object. It can also be described by the area occupied by objects in the image.

We can model shape through the description of the shape. It need analyze the shape, extract characteristics which can express the shape, then form the shape description vector. The purpose of shape description vector is to depict shape. The choice of description method depends on application. To meet the request of the recognition, shape description just contains information to distinguish similar shapes. It does not require reprintation. So target recognition by the shape is of great significance.

A. *The Current Situation of the Development of Shape Recognition*

Shape as an important part of visual perception, has been brought to the attention of the researchers. Research on shape is becoming more and more mature and complete. In recent years, a lot of representative research has appeared which is mainly divided into three parts: shape extraction, shape description and shape matching. Shape extraction means the precise segments of the target from the background which is the main research contents of image segmentation. Due to the diversity of everything in the world, it is difficult to segment the target from the complex image. This is a big obstacle to current computer vision research. The shape description is to use a particular sequence to depict targets. Good shape description helps shape matching and is also used in shape matching and recognition.

Shape matching has been widely applied in computer vision and other fields but there are still many problems. And related research is very active in recent years. Some applications are challenging, such as digital recognition, trademark retrieval, behavior recognition, target recognition, and part of the body posture estimation. These applications benefit from the correctness and validity of shape matching technology. In different applications, methods are different. At the same time it also needs different matching algorithm to deal with a variety of shapes. With the progress of the current technology, the development of science and the wide application of network, data which need to deal with are also growing. There is an urgent hope that computers can help people to solve various problems well. So even the study of shape matching is more and more mature, getting better effect on effectiveness and computational complexity are challenge for these researchers.

B. *The Key Technology of Shape Recognition*

At present, the study of shape mainly can be divided into the study of shape descriptor and the study of shape matching.

1) *Shape Description:*

- Shape description is to use a specific sequence to represent the shape of space information. Shape description is the base of the applications of shape matching, recognition and retrieval. After decades of development, there are many shape analysis methods used to obtain space information in computer vision field. According to the extraction process of the shape, feature descriptor can be divided into shape signature, polygonal approximation method, spatial interrelation feature, invariant moment, curvature scale-space and the shape transform domain.
- Shape signature is a method used to extract shape information from the boundary of shape. Shape perception is extracted. There are many common signature technologies, such as centroid distance function, tangent angle, curvature function, area function, chord length function, etc. Shape signature uses a one-dimensional function to represent the shape outline which is more sensitive to noise. Tiny

changes of boundary will lead to matching errors. So generally speaking, it is not directly used for shape matching, instead it will go through certain processing before the operation.

- Polygon approximation obtains the overall information by ignoring tiny changes on the edge of shape to reduce the influence of the shape boundary discrete pixels. There are generally two means to implement polygonal approximation: merging and splitting. Polygonal approximation is simple and cannot be directly used in the comparison of the shape, but usually used in the preprocessing part of the shape.
- Spatial interrelation feature takes advantage of curve or pixel to describe shape. In general, this method uses the geometrical characteristics to represent the shape, such as length, curvature, relative direction and position, area, and distance, etc.
- Invariant moment is a concept in physics, using the invariant moment theory to analyze effectively the outline of target shape and area. Boundary moment can be used to reduce dimension of shape boundary. Zernike moment has many good characters, such as scale invariance, robustness of noise and tiny changes, but it is more complex to compute.
- Curvature scale-space (CSS) is a shape descriptor put forward by F. Mokhtarian in 1988. CSS represents the shape based on multi-scale curvature. It has many good features, such noise robustness, scale invariance, and rotation invariance. It is also reliable and easy to calculate.
- There are some methods based on the shape transform domain, such as Fourier descriptor, and wavelet transform. Fourier descriptor computation, which is simple and has robustness to noise, has been widely applied in different fields. Wavelet transform decomposes the curve of shape into different scales. It uses the rough dimension elements to express approximately global information of the shape and uses good dimension elements to represent the local information of shape. Wavelet transform has many good properties, such as multiple methods expression, scale-invariant, consistency, and stability, etc.

2) *Shape matching*

- Shape matching measures the similarity of the two shapes according to certain standards based on the shape description, as well as completes two descriptors set index and deals with all kinds of shape changes during matching.
- Shape matching usually records similarity between features of points on the shape through establishing cost matrix. Similarity can be represented by the distance of the shape descriptor. Points matching solves the assignment problem (AP) based on the cost matrix. Bookstein first used thin plate spline (TPS) to mark points matching. It is the only spline function that will decompose clearly mapping into

rigid and non-rigid. It uses joint methods to obtain matching matrix and the mapping parameter between solution point sets by minimizing the TPS bend, under the condition of guaranteeing constraints of one to one between point set.

- Chui H.L and Rangarajan A presented a robust point matching (the RPM) algorithm. The method evaluates corresponding relation and the non-rigid change between two point sets, which have different sizes. The algorithm implements correspondence between the non-rigid object by soft allocation and thin plate spline. Shape similarity is often represented by distance. Calculation for two shapes optimal matching equals to find mapping which meets one-to-one matching minimum distance. In addition to using two parts graph matching, it can also use the Hungarian algorithm. Maciel and Costeria solved the problem of minimum integer constraints by concave programming and relaxed treatment. Zheng and Doermann improved the shape context by maximumly retaining the dichotomy of neighbor information. Liu solved matching by using dynamic programming algorithm, which shows a good matching performance. Scott and Nowak used point order restriction during matching. They used the dynamic programming algorithm too. But the calculation is very complex.

C. Mainstream Shape Recognition Algorithm

At present, many good shape detection and recognition algorithms have been put forward. Hough transform is one of the basic tools of graphic detection. If the parameter space is no more than two dimensions, the transformation could get ideal effect. But when it is more than that, Hough transform greatly assumes more computing time and storage space, which causes its low operation efficiency and badly limits its practical application. Although people have put forward many improved algorithms, such as randomized Hough transform, calculation is still large during dealing with the complex image. Wu Jianping put forward a fast circle detection algorithm in his paper "Real-time Robust Algorithm for Circle Object Detection". It is different from Hough transform in the following aspects: The algorithm uses a set of links or edge pixels meeting specific related rules to calculate circle radius and center position. It is different from statistical distribution mechanism used by Hough transform; The algorithm could get faster detection speed than algorithms based on Hough transform; The algorithm could detect circles very accurately. The algorithm is also applicable to ellipse detection after making some changes. Wu Jianping also published papers in this respect, "Robust Real-time Ellipse Detection By Direct Least-Square-Fitting" and "Real-time Automatic Road Sign Detection".

The angular point, tangency and inflexion point on the image boundary, are important characteristics of the target

shape. They have many good features, such as rotation and scaling invariance. Angular point is the local maximum which exceeds a certain threshold on the boundary of the target curvature. Tangency point is smooth transition between linear and circular arc. Inflexion point is smooth transition point between concave and convex arc. As angular point is more important than the tangent point and inflexion point, people have paid great attention to it. Ning Li put forward a kind of angular point extraction algorithm based on average chain code according to its features. The new algorithm uses the average chain code difference calculation to replace completely curvature calculation which is used in algorithms based on Freeman chain code. It reduces computational complexity to linear. The experimental results showed that the new algorithm had more resistance to noise, accuracy and stability. In addition, it put forward a simple and effective free curve linear approximation algorithm using the chain code technology. This method is not only applicable to the straight line, arc and non-circular curve, but also to complicated shape, free curve which can't be represented directly by elementary analytic function. Zeng Gang used inflexion point to identify the damaged image while Chen Lijun identified buildings through angular point.

IV. CONCLUSION

The shape identification technology has been widely used in many fields. The technology has made great development and a large number of excellent algorithms are proposed. But due to the complexity of image and the diversity of applications, there is no unified theory and generic algorithm to solve all problems. Most algorithms are designed to solve the problem of a particular application domain. These problems motivate scholars to study and explore continuously.

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