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Overview of Color Image Segmentation Methods

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ABSTRACT. *With the rapid development of artificial intelligence technology and computer vision, image segmentation technology has become the core problem to be solved in the image processing process in machine vision.Color image has become a research hotspot because it has more information than gray image and is easy to recognize objects.In this paper, the existing color image segmentation algorithms are systematically reviewed, their advantages and disadvantages are analyzed, and the future development direction of color image segmentation technology is prospected in the conclusion section.*

KEYWORDS: *Color Image Segmentation; Color Features; Area Growth Points; Watershed; Neural Network*

1. Introduction

In recent years, machine vision has been widely used in all areas of our life. Image processing is the basic problem of computer vision.Image processing can also be divided into feature extraction, image segmentation and semantic division.The accuracy of image segmentation seriously affects the accuracy of visual recognition.At present, the segmentation principle of traditional gray-scale image is relatively simple. This part of the research results are more mature, but the segmentation of color image is less studied because of its complexity.

The main difference between gray image and color image is that from the principle of image segmentation, the spatial dimension of pixels is different. Gray image is in one-dimensional brightness space, and color image is in three-dimensional color space.Grayscale images describe the knowledge that the surface shape of an object is difficult to recognize, while three-channel RGB color images accurately describe the authenticity of the object.In general, it is necessary to study the color image segmentation methods.The main purpose of this review is to make a systematic summary of the current status of image segmentation technology, and to propose prospects for the future development, and to provide a reference for more researchers in this field.

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2. Color Image Segmentation Method

There are many classification methods for color image segmentation according to different classification criteria.For example, by classifying color and spatial characteristics, we can classify them into supervised and unsupervised classification problems.Early methods applied to gray-scale image segmentation can also be applied to color image segmentation, such as histogram threshold method, adaptive fuzzy algorithm, artificial neural network algorithm, and so on.At present, the main methods of color image segmentation are region-based methods, histogram thresholding, feature spatial clustering, edge detection, fuzzy technology, artificial neural network and physical model-based methods.We will discuss these methods below.

2.1 Region-based Approach

2.1.1 Regional Growth, Division, Merger and Their Combinations

The essence of region growth is to gather almost the same pixels together to form an area. Region splitting is just the reverse process of the former. It usually divides the seed area into four rectangular areas, and then decomposes each rectangular area according to the pixel similarity.Existing research generally combines regional growth with regional division to form regional fusion and to form larger subregions.When parts of the image have the same characteristics, these methods have a good segmentation effect and are not disturbed by external noise.The order of growth and the selection of seed points have a great impact on the accuracy of regional growth techniques, and the number of regional splits will also destroy the boundary and ultimately affect the splitting effect.Therefore, region merging can improve the shortcomings of both methods.

2.1.2 Watershed Segmentation Method

Watershed segmentation is inspired by the concept of topography and landform, and is an important algorithm of image morphology.When using watershed to segment an image, we first extract the sexual features, then use the watershed algorithm to find the area of interest based on the gradient signal of the image.Extracting the area of interest is a challenge for watershed algorithm [1], if the selection does not affect the accuracy of image segmentation too much.Therefore, in order to obtain useful local extremum points to determine the area of interest, Shafarenko et al. used the original image to fill the "pseudo" Valley floor, using the morphological "closed" operation [2].Shi-ji et al. tagged the image based on a "closed" fill operation on the histogram and selected areas where the existing image and the original image had little change [3].Lezoray uses a Bayesian classifier to search for the tag in the original image[4-8]. At the beginning of segmentation, Marie Hong et al. preprocessed the result of image on-off filter as a binary marker, and then input the result into the micro-watershed algorithm.

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2.1.3 Method Based on Random Field

Markov random field is the most widely used statistical algorithm in image segmentation. Its principle is to treat the RGB value of each point in the image as a random variable with probability distribution.According to the statistical principle, random field refers to the combination of targets that can be correctly segmented by the maximum probability; if based on Bayesian principle, random field image segmentation utilizes the maximum posterior probability distribution.Markov Random Field image segmentation is a local area-based segmentation method, Hammersley-Clifford theorem, whose neighborhood pixels determine the values of each point in the image.The image segmentation process based on Markov random field consists of two phases: coarse segmentation and fine segmentation. The general process is to use spatial filter for coarse segmentation and Markov random field for fine segmentation.In image segmentation, the scale spatial filter is responsible for extracting the number and extent of clusters required in the subdivision stage, and processing each color component to obtain a coarse segmented image [9, 10].

2.2 Histogram Thresholding

Histogram threshold method was first applied to gray-scale image segmentation, and the technology is mature.The difference between a color image and a gray image is that a color image is a three-dimensional color space. Therefore, the histogram corresponding to a color image is a three-dimensional array. As the dimensionality increases, the determination of its threshold is a challenge.For this reason, Underwood proposed a method of projecting three-dimensional space to low-dimensional space to determine the histogram threshold, and carried out corresponding experiments, the results show that the method is feasible.Kurugollu et al. proposed a multispectral color image segmentation method. FRG, FRB, and FGB were selected as the spectral subsets at the beginning of the segmentation, then the spectral subsets were processed by multithreshold, and then the fusion algorithm was used to synthesize the histogram of the spectral subsets to segment the image.The histogram threshold method can effectively eliminate unnecessary prior information and reduce computational effort.However, monochrome segmentation can result in loss of area, making complex image processing more difficult.

2.3 Feature Spatial Clustering

The feature spatial clustering algorithm is an unsupervised segmentation algorithm, which avoids the problem of too much computation and too high cost caused by a large number of samples.Its principle is simple, mainly using continuous iteration to obtain the image's eigenvalues.Among our existing methods, K-means and Fuzzy C-means are widely used.The flow of the feature spatial clustering method is to determine the number of clusters mainly through cluster validity analysis.Color image segmentation uses color space clustering to make full use of the information of three color spaces compared with other methods, so it is easier to

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achieve. Although the method of feature spatial clustering eliminates the tedious work of training image data, the determination of initial parameters and number of classifications is still a big problem. This method is greatly affected by noise.

2.4 Edge Detection

There are many existing edge detection technologies, among which gray edge detection technology has more applications.Its basic principle is based on the three-dimensional space of the color image, using the root mean square, sum, maximum absolute value and other merging methods to process the color component to determine the final result.However, this algorithm based on gray scale edge detection does not always get accurate results. Edge detection based on gradient edge operator may lead to different directions.To solve this problem, Trahanias et al. proposed the concept of vector field, that is, color image is treated as an ordered vector sample, and edge detection operators are determined according to the linear combination amplitude of these samples.Existing research centers can also be solved by dimension reduction.The main advantage of edge detection is that the segmentation results are good, when the significant areas are more conspicuous, but sometimes the edge detection operator is too large or too small, which will cause the quality of the segmentation to decrease.

2.5 Fuzzy Technology

Fuzzy technology is often used to deal with the uncertainty of image analysis and pattern recognition.This uncertainty comes from the output of the sensor and propagates during data transmission.Generally speaking, the uncertainty caused by randomness can be solved by statistical principles, while the uncertainty caused by fuzziness can be solved by fuzzy set theory.The fuzzy set mainly consists of three parts: the fuzzy measure, the fuzzy set theory and the fuzzy inference. It can better solve the widespread uncertainties in image segmentation and has become the main development direction of image segmentation technology.In addition, the fuzzy measure and the fuzzy integral model[11, 12] proposed by Sugeno can be used as aggregation operators for many attributes of fuzzy information, which can retain a lot of useful information in image segmentation.Fuzzy technology can solve the negative impact of sensor uncertainty, but it takes a lot of computing time for fuzzy operation.

2.6 Artificial Neural Network

Artificial Neural Network (ANN) is a bionic algorithm with the advantages of non-linear solution and parallel operation, which can handle image segmentation well.The main applications of neural networks in image segmentation are Hopfield neural network, self-organizing network and BP network.Campadelli proposed a segmentation algorithm based on Hopfield neural network for color image segmentation.The traditional self-organizing mapping algorithm has poor

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recognition ability, so papamarkos et al. added a three-node single-layer feed-forward network to the traditional algorithm, implemented the principal component transformation [13], and used the eigenvectors trained by the neural network to obtain the covariance matrix of the color component.BP network is widely used in image segmentation, such as Leseure et al. BP network is used for color image segmentation. The experimental results show that the segmentation effect is good and can accurately process image analysis problems.The neural network algorithm uses training sets to segment images in color image segmentation and is more accurate than the previous methods.However, the training sample data needed is large and the computation time is long, which will reduce the real-time performance of image recognition.

2.7 Method Based on Physical Model

The existing color image segmentation methods are based on the principle of color similarity to define the area. Using this method, the color image of spot and shadow areas will be difficult to be segmented, which makes the target surface uneven, that is, there is some difference between the area boundary and the target boundary.Although HSI solves this problem to some extent, the color phase may be unstable at low saturation.Some scholars have proposed some physical model-based segmentation methods to solve this problem, and used three-dimensional color space modeling.This method is simple to model, but has too many constraints and high requirements for the external environment. Therefore, it has a small application range and only for some specific situations.

3. Conclusion

This paper discusses the importance of color image segmentation in image processing, and systematically reviews the current research status of area-based methods, histogram thresholding, feature spatial clustering, fuzzy technology, edge detection, neural networks and physical models.These methods have their inherent drawbacks. They are often reconstructed by combining these segmented image techniques, and learn from each other, such as clustering and fuzzy methods. Fuzzy clustering fuzzy methods emerge to define regional growth criteria. Histogram analysis determines the structure of the neural network.According to the existing research results, color image segmentation technology does not form a systematic architecture, and a single method is used for specific image applications in the existing research results.In other words, the existing research segmentation methods cannot be applied to any color image segmentation.Theoretically, the gray-scale image segmentation technology is mature, and its segmentation method can be converted into color image segmentation.However, there are many problems to be solved in practical application. Gray image color space is one-dimensional, and merging a specific method is only suitable for processing a single color component, while color images are three-dimensional. When color vectors are projected, their

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RGB information will diverge, resulting in loss of information.Therefore, our future research will focus on how color information is considered as a whole.

In recent years, more and more attention has been paid to fuzzy methods, which are widely used in the field of image segmentation with remarkable results.Although image recognition methods deal with the uncertainty of the image, it takes some time to process the uncertainty of the image, so it is an effective method to blur the image.Most importantly, fuzzy inference can also personify decisions.Therefore, with the advent of the era of big data and artificial intelligence, as well as the improvement of our computing and processing level, the fuzzy method can achieve unexpected results.In addition, because the change of illumination can affect the surface color of the imaging target, and segmentation algorithms are required to eliminate the influence of illumination for applications such as robot vision systems, color invariance-based segmentation algorithms will also receive more and more attention.

References

[1] Lezoray O, Cardot H. Cooperation of color pixel classification schemes and color watershed:a study for microscopic images[J].IEEE Transactions on Image Processing,2002,11(7):783-789.

[2] Shafarenko L,Petrou M,Kittler J.Automatic watershed segmentation of randomly textured color images[J].IEEE Transactions on Image Processing,1997,6(11):1530-1544.

[3] A.S J,Hamada N.Color image segmentation method using watershed algorithm and contour information[C]//Proceedings1999 International Conference on Image Processing (Cat.99CH36348). 24-28 Oct. 1999, Kobe, Japan. IEEE, 1999:305-309.

[4] Fang, L., QIU, T., Zhao, H., & LV, F. (2019) “A hybrid active contour model based on global and local information for medical image segmentation”. Multidimensional Systems and Signal Processing, 30(2), pp.689-703.

[5] DERICHE, M., Amin, A., & Qureshi, M. (2019) “Color image segmentation by combining the convex active contour and the Chan VESE model”. Pattern Analysis and Applications, 22(2), pp.343-357.

[6] ALBANESI, G., GIANNINI, A., Carbone, M., Russo, E., MANNELLA, P., Ferrari, V., & SIMONCINI, T. (2019) “Computed-tomography image segmentation and 3D-reconstruction of the female pelvis for the preoperative planning of SACROCOLPOPEXY: preliminary data”. International UROGYNECOLOGY journal, 30(5), pp.725-731.

[7] Liu, F., Chen, Z., & Wang, J. (2019) “Video image target monitoring based on RNN-LSTM”. Multimedia Tools and Applications, 78(4), pp.4527-4544.

[8] Zhu, B., Wang, X., Chu, Z., Yang, Y., & Shi, J. (2019) “Active learning for recognition of shipwreck target in side-scan sonar image”. Remote Sensing, 11(3), pp.243.

[9] Zhang, Y. D., Dong, Z., Chen, X., JIA, W., Du, S., Muhammad, K., & Wang, S. H. (2019) “Image based fruit category classification by 13-layer deep

ISSN 2706-6827 Vol. 2, Issue 8: 61-67, DOI: 10.25236/IJFS.2020.020808

convolutional neural network and data augmentation". Multimedia Tools and Applications, 78(3), pp.3613-3632.

[10] ELOLA, A., ARAMENDI, E., IRUSTA, U., PICON, A., Alonso, E., Owens, P., & IDRIS, A. (2019) "Deep Neural Networks for ECG-Based Pulse Detection during Out-of-Hospital Cardiac Arrest". Entropy, 21(3), pp.305.

[11] Gray, P. C., Fleishman, A. B., Klein, D. J., MCKOWN, M. W., BEZY, V. S., LOHMANN, K. J., & Johnston, D. W. (2019) "A convolutional neural network for detecting sea turtles in drone imagery". Methods in Ecology and Evolution, 10(3), pp.345-355.

[12] Li, X., Zhang, S., Zhang, Q., Wei, X., Pan, Y., Zhao, J. & Yang, F. (2019) "Diagnosis of thyroid cancer using deep convolutional neural network models applied to SONOGRAPHIC images: a retrospective, MULTICOHORT, diagnostic study". The Lancet Oncology, 20(2), pp.193-201.

[13] SEKAR, V., Zhang, M., SHU, C., & KHOO, B. C. (2019) "Inverse Design of Airfoil Using a Deep Convolutional Neural Network". AIAA Journal, 57(3), pp.993-1003.