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Research paper

Performance comparison and evaluation of various segmentation methods

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Abstract

Image segmentation is the most important method in the concept of image processing. It helps in analyzing the image accurately in many applications. It is generally used to assign or name, a label to individual pixels in an image, so that labels with similar name share common features. These related pixels result in same color, texture, or intensity. It also helps in identifying lines, curves and objects. These kinds of results help in different applications in the field of medical imaging, 3D constructions, etc. There are different kinds of segmentation methods already available for such applications. This paper briefs and compares three different types of segmentation methods like multi-threshold method, watershed method and normalized cut method. It is compared based on computational time, complexity and number of clusters of the different methods used in the image.

Keywords: *Multithreshold; Watershed; Normalised Cut.*

1. Introduction

Image processing is the process of performing operations on the images. It also involves a method of enhancing the images and analyze information from those images. There are algorithms, which are used to perform analysis of the image. When such algorithms are used, it helps to avoid noise problems or distortion during the processing of the image. Segmentation is one of the process of image processing wherein the input images while processing, divides or subdivides into pixels or group of pixels. The main goal of the image segmentation is to make the images easier to understand in a proper meaningful form. It divides each set of pixels in a form so that pixel share same characteristics and gives proper analyzation results. It also recognizes the objects or subparts of the objects. Image processing is one of the fastest growing technology. It is in use in various applications of research in many fields like medicine, forensics, helping disabilities, documents, industries, arts and sciences, graphics, remote sensing, films, etc.

There are two methods present in image processing [1]. One is analog image processing and the other is digital image processing. Analog image processing signifies the image alteration with electrical resources. The best example of it is televised image. The signal in television is a voltage level, which has an amplitude variation, embodies brightness through the image. This results in alteration of the displayed image. The contrast and brightness controls on the television set assist to adjust the reference and amplitude of the video signal, which results in darkening or brightening, or any other alteration of the displayed image brightness. Digital image processing denotes the processing of the digital images. Using a digital camera or a scanner, the image is converted into a digital form and then operations for processing the images are performed by the digital computer. Many procedures like, enhancing the image, correcting and formatting the images, classification of the images are performed to attain better analysis and results. Best example is an MRI image where the images are extracted and analyzed to enhance the pictorial content. The word digital image processing denotes processing of the 2D image. The main purpose of these types of procedures is to enhance the machine interpretations and human interpretations.

There are three levels present in image processing [2]. Low-level processing, mid-level processing and high-level processing. In low-level processing, preprocessing is performed for image sharpening, enhancing the contrast and reducing the noise. Mid-level processing includes dividing the image into multi regions and identifying the objects for classifying different things in an image. High-level image processing is used in making reasonable sense for the collection of different objects. It includes the process of acquiring, processing and segmenting each part of the image, describing and identifying each part of the image in the scope of digital processing. The basic requirements for processing the image is huge storage which requires a lot of intensity to store pixels in bits, short time storage, frame buffer to an access bunch of images rapidly, different controls like zooming and scrolling and rotating, archiving needs massive storage capacity, display image, different file formats, less bandwidth of the image. Mid-level processing is one of the important processing of the image. Therefore, it requires segmenting the image into different parts with the help of different features like color, value, intensity, texture, and pixels.

Different types of segmentation methods are available for processing. Thresholding method, watershed method, and model based method, edge detection method, clustering method, multi-scale method, trainable segment method, compression based method, region-growing method, histogram based method, equation based method, semi-automatic segment method, multispectral segmenting method, dual clustering method, graph partitioning based method [3]. In this paper, the most common methods like multi-threshold, watershed and normalized cut segmenting methods are discussed and compared. Different steps involved in each method, the advantages of each method and its capabilities are discussed. This helps in analyzing the best suitable method for a particular application.

2. Literature review

A new method of segmenting the image has been proposed in [4]. The surface of the threshold is identified by interpolating the gray levels in the image where the gradient is large which specifies the edges of the object. Different methods of interpolation of data to levels, which is given at the scattered points, are mentioned. Several examples are given by applying one same method for all examples. The results are then compared to thresholding algorithms. The method, which is proposed in this paper, uses gray-level information and combined edge in a simple way to produce a result of good threshold surface and clean the image using the validation process from stains that are caused due to random illumination. Firstly, the image is segmented, and then the gradient magnitude image is derived from the original image. Then, the gradient is thresholded and thin paths are identified by applying a process, which sometimes degenerate isolated points. In boundary areas, locations of maximal slope, which separates from the background, are identified. Maximal gradient is used as pointers to position the gray levels in the original image.

Here, problems with thresholding, local thresholding, methods of thresholding have been described [5]. The main difficulty with thresholding is that only the intensity is considered and any relation among the pixels is not considered. There is a possibility of missing the pixels near the boundaries or any particular region. If the noise is more in the picture than pixel intensity is not recognized. Shadows of the objects are the real problem where there is a confusion of identifying where exactly the light falls. In global thresholding, illumination is the major problem wherein some parts tend to be brighter or darker. Therefore, the threshold is allowed to smoothly vary across the image. The methods of finding the threshold are by identifying the known distribution, finding peaks and valleys, by clustering with K-mean variation, by clustering with Otsu's method and by mixture modelling. At Multispectral threshold, estimation of optimal threshold in a single channel is found and then partitioning the image grounded on that threshold. In thresholding along boundaries, boundary finding methods like edge detection is applied and then sampling the pixels, where the boundary-probability is in elevation.

In this paper, the author has specified how the appropriate value of the threshold can be found using the image histogram [6]. Identification of noise, illumination and reflection of the role, on what basis global threshold happens, Otsu's method, smoothing of the image, the significance of histogram, how border region is selected, usage of the edge for global threshold, image partitioning, region splitting and growing in threshold is explained with formulations and also with image example. The author also mentions the watershed method. A watershed is the technique of transforming the original image, which separates the nearby drainage basins. Border and few nearby basins have a habit of merging. It is performed by applying minimum points on the image. Examples of the images with the watershed method are applied with the pointers are shown. Text based and color based segmentation are applied with examples.

Previous image retrieval methods were created on textual observations of the images [7]. Discrete wavelet transform is used by region based image retrieval system and segmenting the images into regions is used by watershed segmentation. K-means algorithm offers coarse image. A better segmentation technique is applied through k-means technique. For this reason, a new novel texture gradient segmentation technique is established. A non-decimated wavelet packet transform technique is used by texture gradient to properly segment the regions. A marker algorithm is helpful in locating textured and non-textured regions. The paper demonstrates this technique upon k-means technique.

The paper improves the former image segmentation algorithm by combining watershed and adaptive threshold technique [8]. The wavelet transform is applied initially for accurate information. An adaptive threshold helps in eliminating smallest gradient value based on gradient magnitude approximation. Then the watershed method is applied. The result shows that noise has been decreased immensely. During the process, the focus was on the edges and noise on the image.

For contour extraction in gray image, a non-parametric method is applied [9]. It defines the contours like the variation of the watershed function. Two applications based examples, bubble detection in a radiographic plate and face detection are described here. Mathematical definitions of the object, satisfactory visualization are the advantages of this study. Image can be graphically be segmented. Generally, local features are used to segment an image. However, using graph-partitioning techniques, images can be segmented in a better way. This method shows the variation between different groups and similar in the same groups. This efficient technique is grounded on eigenvalue problem [10]. The cut cost is computed to all the nodes in the graph. The Ncut value related to the isolated nodes will have a huge percentage compared to the total measure. Eigen vector can be applied to the second smallest value to segment the graph into two parts.

The paper [11], specifies a new procedure on color image which is applied by combining twice-used Ncut and watershed method. The watershed method is segmented twice to produce more partitions. These regions are presented in a graph and used as input for the normalized cut algorithm. A new matrix assigned with weight is used additionally in this paper. Computational complexity is reduced in the usage of Ncut method. This proposed method has higher performance, value and reduced computational cost. The particular regions developed during the second segmentation are represented as nodes. While constructing the matrix, the space and the color, position are considered and attains adaptability.

The paper [12] compares the MR images with different segmentation techniques. Initially, the images are segmented and then a 3D based model is created. From that model, the analysis of suitable segmentation method is performed. The main goal of the method proposed is to eliminate the traditional way of processing. The method uses edge level segmentation and analysis the volume of the tumor so that the result gives the exact output by using normalization of pixels present in the image.

A marker-based method is used in watershed algorithm [13]. A new method is applied on superpixels by using watershed transform method. It produces the partitions very efficient. The complexity of this waterpixel is O (n). This method has been implemented and applied to the Berkeley database and have used state of the art method for comparison. The state of art method is based on k-means clustering.

The Otsu's algorithm of threshold technique is analyzed and improved so that the computational time is reduced and gives the results faster [14]. The results are analyzed based on one-dimensional Otsu algorithm, two-dimensional Otsu algorithm, decomposition of two-dimensional threshold algorithm and the proposed algorithm. The complexity of the algorithm is O (n2). The experimental analysis results that two-dimensional Otsu algorithm is better when compared to all.

A new method has been proposed to improve the efficiency of graph-based approach [15]. The new algorithm uses few metrics, which is based on greedy algorithm. It works in linear time with high and low variability. The complexity of this algorithm is O (nlogn). The weights are assigned to the graph to find the variability. The metrics are used to analyze the boundary region value. With this proposed metric, new graph, based approach is proposed.

Table 1: Existing Techniques and Authors Contribution

Method Name	Author name	Contribution
Threshold	Kun Yang, Cai-Xia Deng, Yu Chen, Li-Xiang Xu	To remove the noise effectively, improvement of threshold function is used [16].
Threshold	Xue Dong Yang, V. Gupta	Histogram is used to improve two existing methods, Otsu and Wang [17].
Watershed	MingZhang, LingZhang, H.D.Cheng	To segment the image, neutrosophic method is applied with the watershed algorithm [18].
Watershed	Thomas P. Hollenhorst, Terry N. Brown, Lucinda B. Johnson, Jan J. H. Ciborowski, and George E. Host	The authors for indicator development in coastal ecosystems have provided different approaches [19].
Normalised Cut	Najmuzzama Zerdi, Dr. Subhash Kulkarni , Dr. V.D.Mytri	Image is analysed, segmented, and divided into clusters using weighted pixel parameters [20].
Normalised Cut	Wenbing Tao, Yimin Zhang	An improved strategy is used for segmentation of colour images [21].

3. Methodology and implementation

3.1. Threshold method

One of the simplest methods of segmentation is image processing. Thresholding method is used in creating binary images from gray-scale images. While processing, each pixel is marked as objects, when the value is greater than particular threshold value and back-ground pixels when the value is less than the particular threshold value. This background pixel is assigned value of 0 and the object pixel is assigned value of 1. Multilevel threshold is done by using Otsu’s method. Quantization in this process is used to compress the particular range of values to a single quantum method. It is also used to segment the labels. The thresholding is found by histogram aggregation of the whole array. A search-based optimization of Otsu’s method is used here to identify the threshold. This search-based method finds the minimum of the input value based on the argument. This returns only optimal value. These values are used to represent local values, which are similar.

3.2. Watershed method

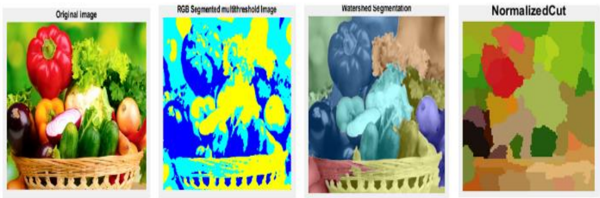
A watershed is applied to a grayscale image. It divides the drainage basins in an image. It identifies the ridges and lines, which run on top of it along with the intensity of each point. This technique can be applied on the edges, nodes, or both. Different kinds of algo-rithms are being defined for this technique. Watershed transform is computed based on specific connectivity. Watershed by default uses 8-connected neighborhood for 2D image. For a 3D image, it uses 26-connected neighborhood for a 3D image. For 2D image, from two overlapping circular objects a binary image is made. Complementary of the binary image is then used to compute the binary image. Pixels, which do not belong to the particular region, should be in a different region. By making the background pixels to zero, the watershed transform is computed and the image is dis-played in an RGB format.

3.3. Normalised method

There are sets of points in an image where the points can be repre-sented with weights and as undirected graph. These points are rep-resented as the nodes. The weights present in the edges of the image is said to be the function. The partition of the each vertex set in a graph is the segmentation. It measures both the similarity in the groups and which are not similar in the group. This technique is based on eigenvalue problem helps to optimize the measure. Eigen value or a vector is a non-zero vector when linear transformation is applied changes by overall scale. Initially, the optimal partition cut is found. The output from this step finds the minimum partition cut. This cut value is passed to the minsearch to find the most optimal and accurate value and to minimize it. Firstly, the weight matrix is analyzed. Spatial location's distance is found. Feature vector dis-similarity is identified. Secondly, eigenvalue system is applied to find the transformation of the vectors. The current position, which may or may not be divided, is checked. These can be iterated until one segment is over. Therefore, the same applies to both the seg-ments and concatenated. The colour, special data, ncut value and threshold value, size of the area are given as input to compute the normalised cut technique.

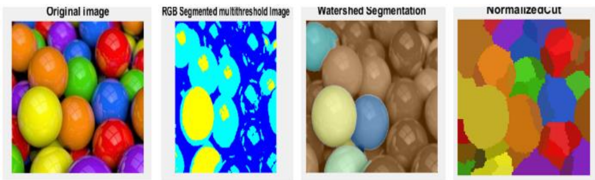
4. Experimental result

Three segmentation techniques are implemented in this paper. Analysis is performed to evaluate the results of each technique and bring out which technique can be applied for different applications.



(a) Original image (b) Multithreshold (c) Watershed (d) Normalised Cut

Fig. 1: Basket of Vegetables.



(a) Original image (b) Multithreshold (c) Watershed (d) Normalised Cut

Fig. 2: Bunch of Balls.

(a) Original image (b) Multithreshold (c) Watershed (d) Normalised Cut

Fig. 3: Bouquet of Flowers.

Compared to the fig. 2, fig. 1 and fig. 3 shows good results for the given input image. In fig. 2, since the reflection on the balls is a little high, the image does not show accurate segmentation in all three types of segmentation. There is a color variation for all three types of segmentation methods. In fig. 3, since the object color is darker than the background in the original image, the coloring of the object in the normalized cut method and watershed method is same for the whole object and the light colors are allotted for back-ground regions automatically. The fig. 1 shows results appropriate for the given image.

Thresholding is mostly applied to binary images. Best example is to read the text. Mutlthresholding is nothing but segmenting more number of regions. Best example for multi thresholding is the image which contains light emission around a particular region. It can also be used in finding darker and lighter shades of light. Watershed technique can be applied to find different objects and similar kind of pixel related. Best example is clustering. Normalised cut per-forms segmentation by graphical means. Very small regions can be found and analysed for different interpretations. Best example is medical diagnoses and compression of image.

Based on the metrics in table 2, the watershed method has computational time 6.6406s and with O (n) complexity. The multithreshold method has 2.5313s of computational time and with O (n2) complexity. The normalized method has 10.7500s of computational time with O (nlogn) complexity. From these comparisons, the best-case complexity falls on watershed method. The worst-case complexity falls on normalized cut method and the average case is on multithreshld method.

Table 2: Performance metrics comparison of segmentation methods

Segmentation Technique	Computational time	Complexity
Multi threshold method	2.5313	$O(n^2)$
Watershed method	6.6406	O(n)
Normalised Cut method	10.7500	O(nlogn)

Table 3: Number of Clusters Segmented Based on the Methods

Images	Clusters in multi-threshold method	Clusters in watershed method	Clusters in normalised method
	2	7	41
	2	1	49
	2	1	29

The number of clusters mentioned in table 3 depends on the input image and the methods used for that image. The cluster number totally varies from normalized method on different images. The analysis of these segmentation clustering is performed to understand how the images are segmented.

5. Conclusion

Thus, three different kinds of segmentation methods are discussed. Application of different kinds of segments is also briefed. Very importantly, the segmenting techniques should be applied based on the requirements of the input and usage. Application of different segmenting methods in different use may result in inappropriateness. So suitable methods should be applied to images. In threshold method, the complexity is high even though the computational times are less. Normalized cut has high complexity and computational time. So, from the analysis based on the number of clusters, computational time and complexity, the result shows that the watershed method is better than the other two methods. Further analysis can be performed based on Image quality assessment (IQA). This Image quality assessment is done for the parameters, which are already selected. Thus, by using such method quality for the images can be analyzed. When the image is present with high noise and different levels of shading, the automatic detection algorithm can be applied for analysis.

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References

[1] Manjula. KA, ”Role of Image Segmentation in Digital Image Processing for Information Processing”, IJCST, vol 3,issue 3,pp.312-318,May-June 2015.
[2] Sharma D.,”Image processing”, Course-ECE-411, Technical pa-per.
[3] https://en.wikipedia.org/wiki/Image segmentation.
[4] Yanowitz S.D., Bruckstein A.M.,”A new method for image segementation”, pp.82-95, February 4, 1998.
[5] Morse B.S., Brigham Young University, “Thresholding”, 1998-2000, technical paper.
[6] Ferrari S., “Image segmentation”, pp.1-22, 2011, technical paper.
[7] Amoda N., Kulkarni R.K., “Image segmentation and detection using watershed transform and region based image retrieval”, IJETTCS, vol 2, Issue 2, pp.89-94, 2013.
[8] XUE Guoxin, LIU Qiang, XUE Pei, “Method of watershed with threshold decision for multiscale tra c image segmentation, International Symposium on Computational Intelligence and Design”, pp.186-189, 2010.
[9] Beucher S., Lantuejoul C., “Use of watersheds in contour detection”, pp.2.1-2.12, technical paper, 1979.
[10] Shi J., Malik J., cuts and image segmentation, pp.1-52, technical paper.
[11] Xiaoli Xu, Zhimao Lu, Haiyan Li, “Color Image Segmentation Based on Watershed and Ncut of Improved Weight Matrix”, IEEE, pp.681-686, 2011.
[12] Mikulka J., Gescheidtova E., Bartusek K., and Nespor D., “Comparison of Segmentation Methods in MR Image Processing”, Progress in Electromagnetics Research Symposium Proceedings, pp.429-432, 2012.
[13] Vaia Machairas, Etienne Decenciere, Thomas Walter, “Waterpixels: Superpixels based on the watershed transformation”, IEEE, 2014.
[14] Qian Zhu, Liqiu Jing and Rongsheng Bi, “Exploration and Im-provement of Otsu Threshold Segmentation Algorithm”, IEEE, 2010.
[15] Sahil Narang, Kishore Rathinavel, “An implementation of Efficient Graph-Based Image Segmentation”, pp.1-4.
[16] Kun Yang, Cai-Xia Deng, Yu Chen, Li-Xiang Xu, “The denoising method of threshold function based on wavelet”, IEEE, 13-16 July, 2014.
[17] Xiie Dong Yang and Vipin Gnpta, “An Improved Threshold Se-lection Method for Image Segmentation”,IEEE, 1993.
[18] https://www.sciencedirect.com/science/article/pii/S0165168409004423
[19] http://www.bioone.org/doi/abs/10.3394/0380 1330(2007)33
[20] Najmuzzama Zerdi, Dr. Subhash Kulkarni,Dr. V.D.Mytri,” Detailed image segmentation using normalised cuts and weighted coefficient”, IJEEE,April 2014.
[21] Wenbing Tao, Hai Jin, and Yimin Zhang, “Color Image Seg-mentation Based on Mean Shift and Normalized Cuts”, October 2007.