ITERATED MERGING REGION BASED ON THE AVERAGE GRAYSCALE DIFFERENCE FOR INTERACTIVE IMAGE SEGMENTATION

**Biandina Meidyani, Lailly S. Qolby, Ahmad Miftah Fajrin, Agus Zainal Arifin,
Dini Adni Navastara**

Department of Informatics, Faculty of Information and Communication Technology, Sepuluh Nopember
Institute of Technology, Surabaya, 60111, Indonesia

E-mail: biandina12@mhs.if.its.ac.id, laillys.qolby@gmail.com, miftah.fr@gmail.com,
agusza@cs.its.ac.id, dinnavastara@gmail.com

Abstract

Image Segmentation is a process to separate between foreground and background. Segmentation process in low contrast image such as dental panoramic radiograph image is not easily determined. Image segmentation accuracy determines the success or failure of the final analysis process. The process of segmentation can occur ambiguity. This ambiguity is due to an ambiguous area if it is not selected as a region so it may have occurred cluster errors. To solve this ambiguity, we proposed a new region merging by iterated region merging process on dental panoramic radiograph image. The proposed method uses a new distance measurement using the average calculation of grayscale differences in the border of each region. In each iteration, the minimal gray-levels value is merged so the unknown regions significantly reduced. This experiment shows that the proposed method is effective with an average of ME and RAE of 0.04% and 0.06%.

Keywords: *Image Segmentation, Region Merging, Dental Panoramic Radiograph, Iterated Merging Region, An Average Grayscale Difference*

Abstrak

Segmentasi Citra adalah proses untuk memisahkan antara latar depan dan latar belakang. Proses segmentasi pada gambar kontras rendah seperti gambar radiografi panoramik gigi tidak mudah ditentukan. Keakuratan segmentasi gambar menentukan keberhasilan atau kegagalan proses analisis akhir. Proses segmentasi dapat terjadi ambiguitas. Ambiguitas ini disebabkan oleh area yang ambigu jika tidak dipilih sebagai wilayah sehingga dapat terjadi kesalahan klaster. Untuk mengatasi ambiguitas ini, kami mengusulkan penggabungan wilayah baru dengan proses penggabungan wilayah berulang pada gambar radiografi panoramik gigi. Metode yang diusulkan menggunakan pengukuran jarak baru menggunakan perhitungan perbedaan rata-rata skala abu-abu di perbatasan masing-masing daerah. Dalam setiap iterasi, nilai gray level minimal digabung sehingga daerah yang tidak dikenal berkurang secara signifikan. Eksperimen ini menunjukkan bahwa metode yang diusulkan efektif dengan rata-rata ME dan RAE sebesar 0,04% dan 0,06%.

Kata Kunci: *Segmentasi Citra, Penggabungan Wilayah, Dental Panoramic Radiograph, Wilayah Penggabungan Iterasi, Perbedaan Rata-Rata Skala Abu-Abu*

1. Introduction

Image segmentation is the separation of one or more regions or objects in an image based on a similarity criterion [1]. Usually segmentation is the process of partitioning objects from the background [2]. Region-based segmentation considers the gray level of neighboring pixels by inserting similar neighboring pixels, separating and merging pixels. Image segmentation can be implemented in medical imaging.

Medical image is a fundamental tool for a diagnostic task. By using the medical image, detection and diagnosis give better and faster decision. In Dentistry dental panoramic radiograph are used to identify the dental area. Dental panoramic radiograph is a complete picture of all the teeth, mouth and also surrounding soft tissues

by examining 2D X-rays [3]. Dental panoramic radiograph can be used for periodontal disease, diagnose caries, osteoporosis, periapical pathology, tooth abscess, etc. In the other hand, dental panoramic radiograph has noises, low contrast, and uneven exposure so it makes the segmentation process is difficult.

Segmentation on noisy image and low contrast can be improved by combining the automatic segmentation and more information from user, this process called semi-automatic image segmentation method. In semi-automatic, some areas are marked by the user as the background or object that the most similar according to the information and then the system merges the unknown region.

But in segmentation process usually an ambiguity can be happened because of the grayscale value has no significant difference. In this paper we proposed an image segmentation by iterated region merging process on dental panoramic radiograph. This method merges regions which have minimal gray-level value either with background or object until the unknown regions significantly reduced and his experiment give better image segmentation results for dental panoramic radiograph image.

2. Related Work

There is some previous research about image segmentation and dental radiograph. In [1], [3] and [4] have been proposed an image segmentation by using the merging region for the merging of image segments. Three of that research explain the different method of region merging. In [1] the mean shift result will be marked with an interactive image segmentation and continued with the merging region. In [3] also proposed the region merging after interactive image segmentation. Ten discriminant analysis is done. While at [4] iterated region merging-based graph cuts algorithm.

In [5], [6], [7], [8] segmented a dental panoramic radiograph image. This segmented image are used for many requirement especially in dentistry and forensics. However, dental x-rays will be difficult to segment. This is due to the variations in intensity and shape within the same dental x-ray images and from one image to another [6].

Most of the image segmentation from recent research requires manual human interaction or semi-automatic image segmentation of dental panoramic radiograph. In this paper, we introduced a new region merging by iterated region merging process on dental panoramic radiograph image.

3. Proposed method

There are some steps in semi-automatic image segmentation. The first step is region splitting. The second step is user marking. The third step is distance measurement, and then iterated region merging. The flowchart of this proposed method can be seen on Figure 1.

Region Splitting is a method of splitting an image into a series of separate areas. Separate sections will be grouped according to predefined labels [9]. It started from take the image and then computes all pixels it contains some similarity or not. If it is true, then the area corresponds to an entire region in the image. If it is false, the pixel region is split into the four smaller regions. This process is repeated until no further splitting occurs.

In this paper we focus on iterated region merging with the different distance measurement. After region splitting, the input image (I) is divided become several regions K [1, 2, 3, ..., K] which form one cluster without label (C).

$$I = C = \{C_i\}_{i=1,2,...,K} \tag{1}$$

In the interactive method known User marking [3]. It needed the other information from user to give the image criteria of the object and background. User draw a line in the region which is consist of boundary or has high different grayscale value and marked it as background (B) and object (O).

$$B = \{B_i\}_{i=1,2,...,n} \tag{2}$$

$$O = \{O_i\}_{i=1,2,...,m} \tag{3}$$

Where m denotes total of regions that established the object region and n denotes total of regions that established the background area. However, in addition to being divided into object and background, there are clusters that are not labelled. Regions that belong to this unlabelled cluster will then be defined as object or background. So the input image composed of three cluster i.e. background cluster (B), object cluster (O), and unmarked cluster (C):
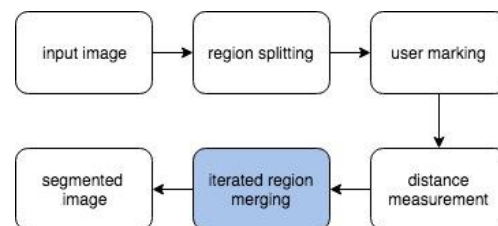
$$I = \{B, O, C\} \tag{4}$$

Figure 1. Flowchart Proposed Method

The difference feature between the cluster that is not clustered into the object group and the background will be measured after the process of determining the sample area of the object and the background. The proposed method for measuring this distance is to calculate the average value of the grayscale difference in the boundary object of each 2 regions. Distance is calculated between unclassified areas to one object and background. The results of this calculation will then be used for region merging.

For distance measurement, the region matrix results are compared with the input matrix to find the boundaries of each region. First, there is a region matrix as follows:

	0	1	2	3
0	0	0	1	5
1	0	1	1	5
2	2	2	2	4
3	3	3	4	4

Figure 2. Split region matrix

Region is divided into two categories, namely the object and the background. For the above matrix, 0 is the region of the object and 4 is the background region. The next region matrix will calculate the difference of border average between 2 regions. The input matrix that contains the following pixel values:

	0	1	2	3
0	1	10	40	150
1	5	35	50	170
2	70	80	90	210
3	150	170	200	220

Figure 3. Grayscale input image matrix

Calculation using the following formula:

$$border[i][j] = abs\frac{\sum_{i=1}^{n}(a_j - a_i)}{n} \qquad (5)$$

Where, i and j are regions. a is the pixel value of the input matrix and n is the number of borders. From the calculation using the formula above, obtained adjacency matrix as follows:

	0	1	2	3	4	5
0	0	30	0	0	0	0
1	30	0	0	0	0	115
2	0	0	0	0	120	0
3	0	0	0	0	0	0
4	0	0	120	0	0	0
5	0	115	0	0	40	0

Figure 4. Adjacency matrix

For this research we focus on the iteration of region merging. After obtaining the adjacency matrix above, the smaller value of the next neighbor is sought for the merging process. The smallest value will be merged into the object or background region. After the region with the average value of the grayscale border are combined by increment of each region, the distance measurements and the merging process of the region are repeated to the unbranched regions of the object and the background until all the region are grouped. The result obtained is a segmented image.

4.   Experimental Results and Discussion

The proposed method has been tested in some image. The experiment tested the proposed method using dental panoramic radiograph image, fruits image dataset and melanoma image dataset (see Figure 5. Image dataset and Figure 6. Ground truth image). The dataset of dental panoramic radiograph is obtained from Airlangga University Hospital. The experiment used 3 dental image radiograph, 3 image of fruits dataset from https://www.vicos.si/Downloads/FIDS30 and 1 image of melanoma dataset from www.isicarchive.com.

We compare the result of our proposed method with other region merging method [3] using both of dataset. The comparative result shown in table 1. In this proposed method, the result of region splitting by Edison system with the marker given by the user is shown on *Figure 7*. The result of the segmentation of the proposed method is shown on *Figure 8*. and the result of segmentation from previous work seen on Figure 9. Evaluation is done by calculating ME (Misclassification Error) and RAE (Relative Foreground Error) [10] with the following formula:

$$ME = 1 - \frac{|B_O \cap B_T| + |F_O \cap F_T|}{|B_O| + |F_O|} \qquad (6)$$

Where B_T and F_T is background and foreground for image segmentation result. B_O and F_O is background and foreground for the ground truth image.

$$RAE = \begin{cases} \frac{A_O - A_T}{A_O} & if\ A_T < A_O, \\ \frac{A_T - A_O}{A_T} & if\ A_T \geq A_O, \end{cases} \qquad (7)$$

Where A_T is the area of segmentation result and A_O is an area of the input image. ME and RAE values range from 0 to 1. If ME and RAE values are close to 0 then the segmentation results are considered very similar to ground truth images.
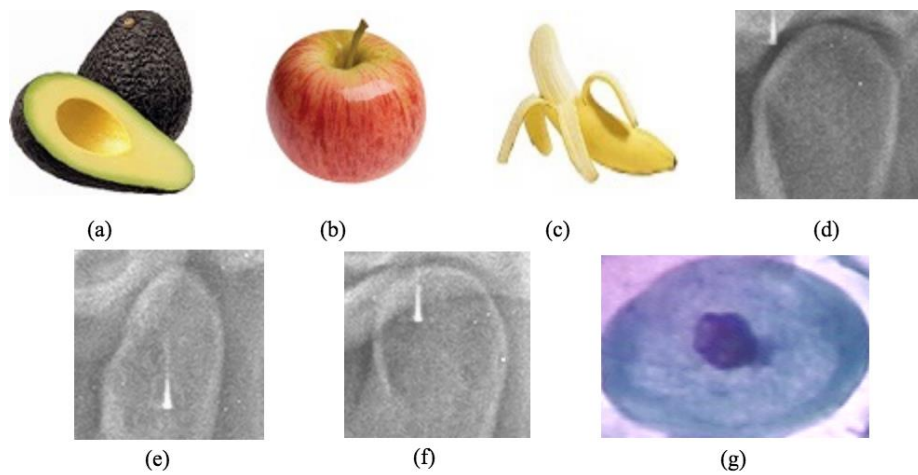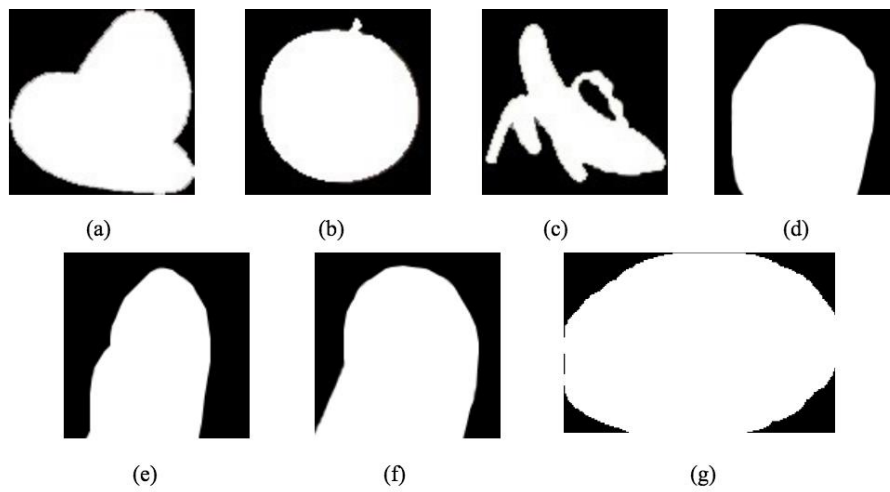
Figure 1. Input Images

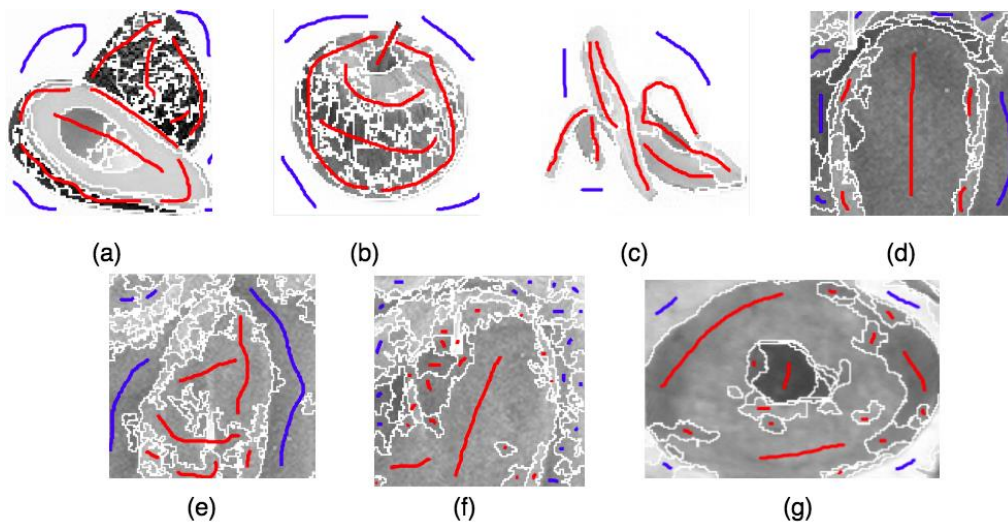Figure 2. Ground Truth Images

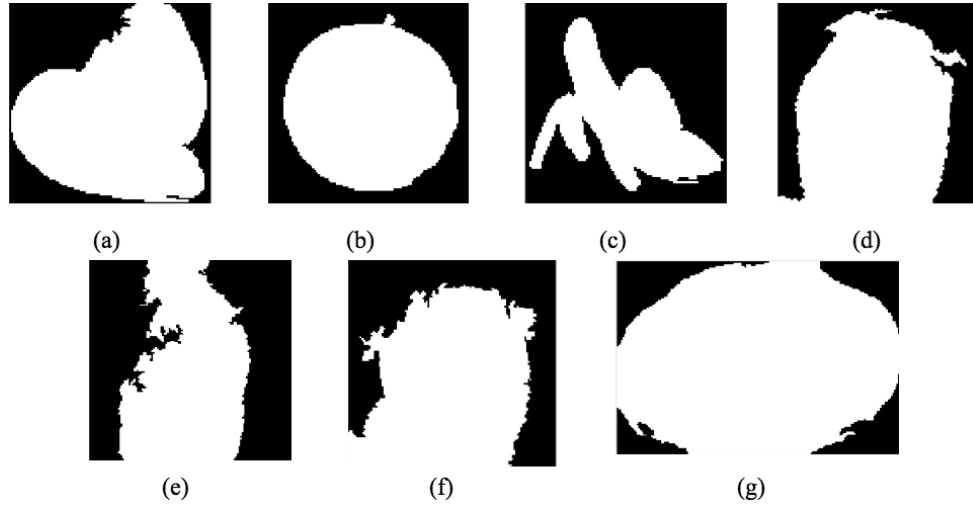Figure 3. Split Region using Edison System and Its Markers

Figure 4. Segmented Image of the Proposed Method

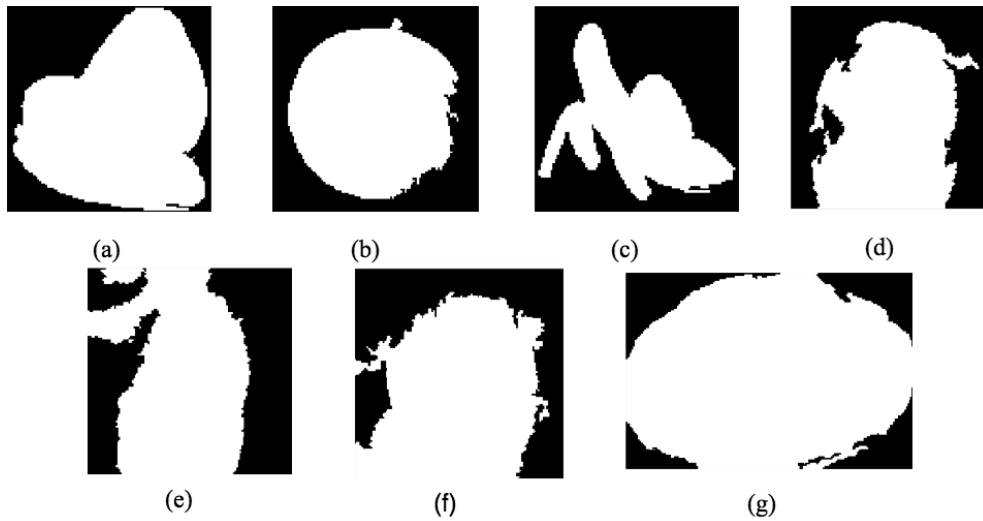
Figure 5. Segmented Image of Previous Method

TABLE 1
THE COMPARISON OF ITERATED REGION MERGING AND REGION MERGING USING STATISTICAL ANALYSIS

Image	Proposed Method		Previous Method	
	ME	RAE	ME	RAE
a	0,0187	0,0273	0,0233	0,0340
b	0,0129	0,0066	0,0394	0,0518
c	0,0357	0,0497	0,0357	0,0497
d	0,0371	0,0293	0,0782	0,0996
e	0,082	0,0165	0,1157	0,1581
f	0,0704	0,0344	0,0802	0,0297
g	0,0255	0,0066	0,0319	0,0169

Table 1 shows the ME and RAE values of the results of the proposed method segmentation comparison and the previous method [3] with segmentation ground truth images. From the evaluation result got the average value of ME from the proposed method and the previous method are 0.04% and 0.06%. The average value of RAE from the proposed method and the previous method are 0.02% and 0.06%. This result shows that the proposed method produces a smaller error than previous method so that the proposed method gives better results.

In *Figure 5*. image (a), (b), (c) there are color image of fruits dataset, (d), (e), (f) are gray image of dental panoramic radiograph and (g) is color image of melanoma dataset where the gray objects and background are similar enough so that the segmentation process cannot be separated accurately. Users can mark some sample objects and backgrounds by using interactive image segmentation so that the segmentation process is done based on the sample. Preprocessing is required by dental panoramic radiography in order to improve the image quality and have a uniform exposure. Images (a) - (c) and (g) result better when segmented due to very clear object and background

differences. The only drawback is because the image has a complex texture that has difficulty when the region splits. The user must provide more sample marking. As for the picture (d) - (f) has object and background that more similar but not textured like the previous picture so that user can give marking which represent some region. With this new distance calculation, there will be consideration of the average value of the grayscale difference on the boundary which will limit it to be merged into one region or not. So as to reduce grouping errors during region merging, we must have the ground truth image as shown in Figure *6* ground truth image is a set of measurements that is known to be much more accurate than measurements from the system.

5. Conclusion

This paper proposed an image segmentation by iterated region merging process on dental panoramic radiograph. In our proposed method, we used a new distance measurement using the average calculation of grayscale differences in the border of each region so that two similar regions if bounded by the boundary, it will not be merged. From the evaluation result got the average value of ME from the proposed method and the previous method [3] are 0.04% and 0.06%. The average value of RAE from the proposed method and the previous method [3] are 0.02% and 0.06%. This result shows that the proposed method produces a smaller error than previous method so that the proposed method gives better results.

To get better result, this method should use an image that has a more distinct grayscale level between the background and the object.

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