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ISBN :
978-1-5386-3085-3
IEEE CATALOG NUMBER :
CFP17CUE-ART

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Semarang | October 7th - 8th, 2017

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Semarang, Indonesia

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IEEE Catalog Number: CFP17CUE-ART

Improve Image Segmentation based on Closed Form Matting Using K-Means Clustering

Yosep Aditya Wicaksono[1], Adhy Rizaldy [2], Sirli Fahriah [3], Moch Arief Soeleman[4]
[1,2,3]Master of Computer Science, [4]Researcher at
Computer Sciences Faculty of Dian Nuswantoro University
Imam Bonjol Street 207, Semarang
Correspond: yosepaw94gaul@gmail.com, adhyc4n@gmail.com, sirlifahriah94@gmail.com, arief22208@gmail.com

Abstraction

Processing image segmentation with image matting technique becomes the current trend of researchers. This paper improves the quality of alpha-matting results from traditional techniques that have been widely used, one of them closed form matting. By combining it with the convergent K-Means clustering algorithm and the iteration process, it's has been shown how to increase the result of image segmentation. The experimental results show that quality improvement is obtained measured by the decreasing in MSE from 4905,77 to 2531,42 for first image, and from 8280,34 to 3813,10 for the second image. For conclusion, clustering algorithm could improve process in digital image matting.

Keywords: image segmentation, k-means, image clustering, closed form matting.

I. INTRODUCTION

Understand and extract information from the image so that it becomes an information that can be used for other tasks is an important aspect of a machine learning [1]. Segmentation of image is the process of extracting information from the image. Image segmentation partitioning the image into subpart based on the region of interest [2]. The purpose of segmentation is to create a representation of the image to be more modest, and often used to find some objects and borders [3].

Compositing, which separating foreground and background is such a technique to do segmentation.

Image matting have come as trademark of compositing technique. Natural image matting and compositing is important in image and videos editing. Formally image matting methods taking as input the image I which is assumed as a combined image foreground F and background image Color pixel b. kth is assumed as linear combinations of foreground and background [4].

$$I_k = \alpha_k F_k + (1 - \alpha_k) B_k \quad (1)$$

where α_k is the pixel's foreground opacity. Matting technique came as essential stage in color segmentation [5]. Otherwise, image matting algorithms can be considered as a special case of soft color segmentation [6].

One of the popular image matting type is Closed form by Levin [7]. One difficulty of this method is to determine the proper number of matting components. Another problem which is an under-constrained problem like other matting approaches is some assumptions must be defined for solving matting problem [8].

Color segmentation in image also need clustering methods. Clustering is the process that depends upon the similarity of pixel values and edge detection depends upon the dissimilarity of pixel values [2]. Clustering algorithm can be regarded as a technique that can be used for classification, particularly the classification of pixels between background and foreground. Clustering algorithm is divided into hard and soft clustering.

One distinguished technique is K-means clustering which is a type of qualitative technique that can work on with large amount of variables. But yield slightly different clusters for different amounts of cluster. It randomly selected a cluster center and chooses an object, which is closest to the cluster center, as a part of the cluster. The whole algorithm repeats itself until the specified goal function is achieved. As a heuristic algorithm, K-Means often mixed with others as hybrid technique [9] [10]. The traditional K-means clustering algorithm can be considered as a soft segmentation method similar with image matting explained above. As it computes both a label as well as a confidence value for each point in the feature space. From this advantage, it's not impossible to use K-means as a solution of closed form matting challenge we have mentioned. An iterative dividing process of K-Means can find enough matting components automatically.

This research uses a combination of image matting with k-means clustering to obtain maximum results of segmentation. We propose the separation process to find [11] sections of this paper are constructed as follows. Section 2 presented the related works of closed form image matting technique improvement and hard clustering K-means. Section 3 & 4 discuss our proposed model to enhances image segmentation, experiments results, and several points discovered. Finally, conclusion and future work are given in section 5.

II. RELATED WORK

Most methods that exist in nature image matting requires input image which must be accompanied by tri map, labels on each pixel as foreground, background or unknown. The purpose of this method is to solve the equation of the unknown pixel compositing. Usually this can be reached by utilizing several local regularity assumptions on the foreground and background to the predictive value of each pixel in the unknown region [4]. Ripali Nirgude and friends [3] Use image repair techniques with the help of different algorithms such as hill climbing K-means clustering, consistency testing, dynamic region merging algorithms, nearest neighbor graphs at different stages. We also study how to check the consistency of areas according to predetermined criteria. This image repair technique is appropriate for future medical and electronics research. The purpose of these paper is to increase the efficiency and tolerances. We can also increase the speed of the operation using advance algorithms [3]. Wu and his friends combine it with the spectral image segmentation matting that lead to useful solutions from image and video editing. They improved the framework for determining the amount of the accuracy of the component matting.

Grouping k-means repeatedly which helping by task distribution is to do segmentation. Partitioning the size of input image to the component images fairly, and with segmentation that hard, can produce results that matting determined the amounts of components, and correspond soft matting components automatically to improving framework. Moreover, it can prevent the situation matting components that consist of both foreground and background objects [11].

III. METHODOLOGY

(1) K-Means Clustering and Closed Form Matting

a. K-means

Main Step for K-means algorithm [12]:

- Define the value of k, and also randomly pick initial centroid.
- Compute the distance from each seed to every cluster that each seed is assigned to the closest cluster. The method using for calculate the distance can be Euclidean distance or other distance.
- For every cluster, the centroid is computed and each seed value is now replaced by the respective cluster centroid.
- Compute the distance again from a seed to each cluster, and the object is allotted to the cluster with the smallest Euclidean distance
- Until object is in same cluster at every iteration ,This process will be continue.

b. Closed Form Matting

Digital matting is the process of extracting the foreground object from the image along with the approximate opacity for each pixel that is covered by the object. This process allows the composition of objects extracted on top of a new background, and it organizes an invaluable tool for editing images, video production, and special effects in motion pictures.

In particularly, the flexibility for image on the background which stimulate cases of natural image matting, attract much researcher [7].

From (1), F_k and B_k stand for the foreground color and background color respectively, and α_k element [0, 1] is the so-called "alpha matte". Equation (1) is also known as the compositing equation, since we can obtain the composed image Ic (2) by replacing original background B_k with a new B_c [13].

A closed form solution is the calculating process with iterate surely until the value of matting components is found. The closed form solution to image matting problem is linked to do optimization. Deriving a cost function from local smoothness assumptions on foreground and background colors. And by eliminate the foreground and background colors they proved that optimal alpha matte by solving a sparse linear system of equations can be found. Compositing equation (1) can be rewritten and approximated by (2) in a small window w. By using (2.1) as the approximation of alpha matte, a cost function is defined by (3).

$$\alpha_i \cong \sum_c a_c I_{ci} + b, \forall i \in w \qquad (2)$$

$$J(\alpha, a, b) \cong \sum_{j \in I} \left(\sum_{i \in wj} (\alpha_i - a_j I_i - b_j)^2 + \varepsilon a_j^2 \right) (3)$$

By define parameter ε (eps) which is the weight of the regularization term on α in (3), and window size solving a sparse set of linear equations. CF method reconstructing F and B is to solve (2) for the optimal a and b given α using least squares. Levin et al use the compositing equation to solve complex foreground and background patterns. Then, introducing some explicit smoothness priors on F and B. Figure 4 shows some results and samples of scribble as sparse input to marking background region and the foreground region.

(2) K-Means + Closed Form Matting

As like as Levin method, Wu and friend [11] Use the eigenvector of the Laplacian matting to obtain the matting component. In our proposed, we Only applies once K-means clustering to the smallest eigenvector of Laplacian matting. Instead, we apply the K-means iterative grouping for the purpose of dividing the group far enough [11]. An iterative dividing process of K-

Means can find enough matting components automatically. Therefor we built a mixed algorithm that combine K-means essential work and basic closed form alpha matting solved equation. Our method is shown like Figure 1.

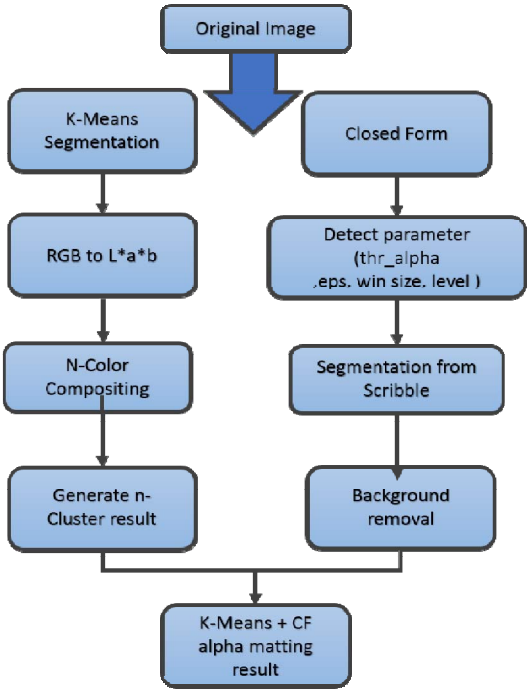

Figure 1. Flowchart of the improved clustering

(3) Evaluation

Segmented image quality was analyzed by using Mean Square Error (MSE) measurement values and Peak to Signal Noise Ratio (PSNR)

1. Mean Square Error: It has been used as the standard measure of the performance of the image output. This gives a lot of output images that deviate from the input image.

$$\text{MSE}(X,Y) = \frac{1}{M\,N}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(X_{(i,j)} - Y_{(i,j)}\right)^2 \quad (4)$$

2. Peak to Signal Noise Ratio: The peak to noise signal ratio is the proportion between the maximum power that can be achieved and the destructive noise affecting similar images. This is used to measure the output image quality.

$$PSNR(X,Y) = 10.\log_{10}\left(\frac{\max^2}{MSE(X,Y)}\right) \quad (5)$$

Figure 2. (a) Original Image: pinky doll, and plants with pot.

IV. EXPERIMENTS AND RESULTS

The original image discussed here (Figure 2), we got from alphamatting.com sample images dataset, a comprehensive online image matting benchmark that most authors has referred.

Figure 3 shows the morphologies of our modified K-Means clustering stages and the alpha results (figure 3) which likely have similarity like Closed Form matting [4]. The foreground and background in the Kid example have similar color distribution. The Koala has large semi-transparent region.

Cluster 2 (4b) outputs in Fig.4 below are subtraction of background removal and result of object separation. Figure 4c shows the Alpha results of our method and compare able with CF method results in Figure 4d. We can see some different of alpha result for the sample images by closed form and by CF combining with our K-Means approach. For quantitative metric, the image Ground truth showed in 4e as standardization of alpha segmentation. We have done the experiment by using scribble image as human intervention input type. Using scribble approach is easier to configure than tri map color technique and reduced the user effort. Scribble image of the pink doll and plant image are shown in Figure 4a. Some example results with sparse user scribbles and several unsuccessful results are excluded in our experiment.

Our proposed work quality could be measure by how good the improvement from Figure 4d before using K-means to Figure 4c after using K-means in algorithm. A good MSE enhancement derived from pink doll with ±2400 difference values. And from second image with ±4400 difference values like Table 1.

Table I. The comparison through MSE (6) and PSNR (7)

Sample Images	MSE (CF)	PSNR	MSE (CF+K-Means)	PSNR
Pink doll	4905.77	13.70	2531.42	16.58
Plant with pot	8280.34	11.58	3813.10	14.94

By subtracted the matting from the original ones (ground truth), shows that with our proposed model Mean Square Error is decreased. Also, with alpha-matting technique PSNR value

(a) (b) (c) (d) (e)

Figure 3. Modified K-Means clustering stages:(a)Original images: kid, koala and teddy bear (b) L*a*b (c)Cluster index, (d) The white & black scribble marked part. (e) Alpha matting object.

(a) (b) (c) (d) (e)

Figure 4. Example results of Our method :(a)Scribble image (b)Cluster 2 from K-means + CF (c)Alpha from K-means + CF (d)Alpha of CF (e)Ground truth image

of each dataset increased. It means this clustering–matting is more details than with basic Closed Form segmentation only.

Overall, we can see that our method got well enough results in proved less MSE or more PSNR. From the results showed that our method suitable for image showing natural images as background. The object in front of the background does not have a complex number of colors. K-Means still use in vast specific research, especially like Image Classification as good prospect as our clustering topic.

V. CONCLUSION

From this work, segmentation of images classified by k-means using basic closed form matting shows improvement. Between K-Means with CF matting and without CF Matting for each sample. The quality of our experiment that analyzed using MSE and PNSR measurement value be compared with other method. MSE measurement from our K-Means + matting experiment prove that quality of image segmentation can be improved by using traditional clustering method. As these final result, the clustering with mixing image matting generate more details better than with a hard K-means clustering or a traditional matting technique only. Further research could be done by constructing more auto iterative approach of K-Means. Some image matting techniques could be implemented as replacement of the CF matting we have used. Another work will be on Fuzzy C-Means which is implemented same concept, means of distance between K-means. In nowadays, some journals work with algorithm of FCM which the next generation of K-means algorithm that may result in a softer segmentation based on fuzzy set theory.

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