Contrast enhancement for satellite image segmentation with fuzzy cluster means using morphological filtering

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Abstract. Image segmentation is a stage in image processing, responsible for dividing an image into regions homogeneous based on the similarity. Suppose the grey level of a pixel by pixel gray neighbors. The quality of image segmentation is generally influenced by the characteristics and the handling of images to be processed. This paper presents the results of satellite image segmentation using a fuzzy cluster region means (FCM). To improve the contrast of the image, conducted morphological filtering techniques. Satellite image analysis performed on five districts in the province of Banten Indonesia. Difference’s segmentation results evident when non-negative parameter value is converted to a 2 and 4. The higher the value of a non-negative parameter is given, then the details of the edges of objects clearer segmentation results. The combined use of a top-hat and boots-hat filtering on objects before satellite imagery analysed by FCM, indicating that it merges with the background object. Background object in the original image is the object of rice fields and is not part of observation in this study. It was identified to have the same gray level similarity with the object of building.

1. Introduction
Image segmentation is the process of pre-processing the image in order to perform the introduction of an object image. Image segmentation divides the image into regions homogeneous in accordance with its neighboring color pixel gray level [1]. Many methods are used for image segmentation among other intensity-based, discontinuity, similarity, graph, Pixon, hybrid methods and clustering [2]. In the discussion of other methods of image segmentation can be realized with some other approaches such as the histogram threshold, clustering (fuzzy and hard), region growing, region splitting and merging, edge-based, physical model- based, fuzzy approaches, neural networks and genetic algorithm [3], [4]. Previous studies have used cluster technique for image segmentation requirements [3], [5], [6].

Cluster technique is used because of its ability to discover the structure of a set of data that does not have a label [3]. In this case, the structure is known as the color pixels that have a different gray level with its neighboring pixels. In addition, the cluster technique also produces image segmentation that is
capable of providing an adequate sense, uses little memory and is faster in performing image segmentation, especially for natural images [4]. On the other hand, the quality of the image will be segmented play a very important role to get better results. One technique for improving image quality is to modify the contrast level before segmental. The development of science in the field of image processing has produced many important approaches for improving the image contrast. Some methods such as histogram equalization, logarithmic image processing (LIP) [7], [8] is used to enhance the contrast in the image quality before entering the stage of image processing. However, the use of histogram's equalization not provide better image quality compared to LIP. Same thing with LIP, despite having results with good image quality, but takes a very long time to be able to produce better image quality [7].

To overcome this, it is proposed another approach to improve image quality by using morphological filtering (MF). The concept of MF has been widely used by some researchers to increase the level of contrast of the image before image processing step. The MF can improve image quality of the detection signal from the non-linear frequency modulated (FM) unknown, although with high noise [9]. Able also eliminates noise and interference in the process of retaining the basic geometric shape of the image [10], [11]. Has a fast process [12], filter out noise remaining [13]. MF can analyze an object's image perfectly [14].

2. Morphological filtering
The MF is a technique used to analyze the shape of the image. An MF works based on two main concepts namely erosion and dilation. Dilation works by adding pixels to the boundaries of objects in the image, while erosion work otherwise. In practice, the concept MF dilation and erosion are often used simultaneously. Morphological opening is the image that is based on the concept of erosion, followed by a dilation process. The Morphological closing is an image analysis process that begins with dilation, followed by erosion. This is then called by morphological filtering [15]. In the development of MF technique has several methods, including the top-hat and boots-hat filtering.

Tot-Hat technique is a method to filter the object image. This technique can reduce the results of the morphological opening (MO). Filtering methods other objects are Bot-Hat techniques. This method can show MO by reducing pixel of the original image of the input. Top-Hat filtering is defined as in equation (1). For example: $f : E \rightarrow R$

An image to grayscale formatting, has a function to map a number of points based on the Euclidean distance, or discrete space E (example $R^2$ or $Z^2$) to in the form of a line that is more real. If given $b(x)$ as a structural element grayscale, then the top-hat transformation is given by the following equation:

$$T_w(f) = f - f \circ b$$

(2)

The operation is called white top-hat, where $\circ$ is a morphological opening operation. Operation black top-hat is the opposite of white top-hat which is defined as follows:

$$T_b(f) = f * b - f$$

(3)

Operator $*$ is a morphological closing operation.

3. Fuzzy Cluster Means (FCM)
Fuzzy C-Means (FCM) was first introduced by Dunn and later modified by Bezdek [16] [17]. The algorithm works iteratively group data so as to form a C cluster membership by minimizing weight and distance data is based on the objective function.

$$F_{FCM} = \sum_{k=1}^{n} \sum_{c=1}^{c} (\mu_{ik})^q d^2(x_k, v_c)$$

(4)

$X = \{x_1, x_2, \ldots, x_n\} \subseteq R_p$ is the set of p-dimensional vector data, n is the number of data, c is the number of clusters with the provisions of $2 \leq c \leq n$, $\mu_{ik}$ is degree of membership $x_k$ for cluster $v_i$, and $q$ is the weight.
of reappointment for each value of fuzzy membership, \( v_i \) is a prototype cluster center, and \( d^2(x_k, v_i) \) is measured the distance between the data objects \( x_k \) and cluster center \( v_i \). Here are the stages of FCM algorithm:

a. Determine the value of each parameter \( c, q \) and \( \varepsilon \)
b. Determine the partition initial matrix \( U = [\mu_{ik}] \)
c. Determine loop counter \( b = 0 \)
d. Calculating of cluster center \( \{v_i^{(b)}\} \) to \( U^{(b)} \) by the equation:

\[
v_i^{(b)} = \frac{\sum_{k=1}^{n} (\mu_{ik}^{(b)})^q x_k}{\sum_{k=1}^{n} (\mu_{ik}^{(b)})^q}
\]
e. Determine the membership \( U^{(b+1)} \). For \( k = 1 \) to \( n \), count the value of \( I_k = \{i \mid 1 \leq i \leq c, d_{ik} = 0\} \); to matrix column \( k \), determine the new membership function by the equation:

i. If \( I_k = \emptyset \) then

\[
\mu_{ik}^{(b+1)} = \frac{1}{\sum_{j=1}^{c} \left( \frac{d_{ik}}{d_{jk}} \right)^{\frac{2}{q-1}}}
\]

ii. Else \( U_i^{(b+1)} = 0 \) for all \( i \not\in I \) and \( \sum_{i \in I_k} U_i^{(b+1)} = 1 \); next \( k \);

f. If \( \| U^{(b)} - U^{(b+1)} \| < \varepsilon \), then clustering is completed. Other than, set \( b = b + 1 \) and repeat steps (d)

4. Research Methods

![Figure 1. The research procedure](image_url)
This study begins with the collection of satellite imagery with Google Map Satellite Downloader application. This study uses five sample districts in Pandeglang, Banten province. The image of the five samples are then converted from RGB format into grayscale mode. Four stages image segmentation: image segmentation with FCM original, then do a top-hat techniques and bot-hat, after that do image segmentation with FCM algorithm. MATLAB software is used in this study as an analysis tool (Figure 1).

5. Result and Discussion

The segmentation process for this study captivated samples in the Pagelaran district. Figure 2 shows a sample image that is still original (before segmentation). The segmentation process is done through the following four steps: (1) determination of parameter FCM, (2) input and reading of data image, (3) conversion satellite image of the YCbCr color (grayscale), and (4) grouping satellite image to segment color image by using FCM.

![Figure 2. Sample of satellite image](image)

Before performing segmentation analysis of satellite images, first set the parameters: number of clusters (c) for image segmentation is 2, the weight of reappointment fuzzy (q) is 2, the smallest error to be expected (є) is 0.0001 and the maximum number of iterations is 100. Satellite imagery will be entered in Matlab, using the format *.jpg /*.JPEG, with a size of 50x50 pixels. Image processing steps initiated by using FCM. Then, to improve the quality to the image is done by using a top-hat filtering. Furthermore, to improve image quality, is used bot-hat filtering. The results of image processing shown in figure 3.

![Figure 3. Satellite images after the improved quality using FCM, Top-Hat and Bot-Hat filtering.](image)
Image processing followed by processing the image size 1116 x 659 pixels, as shown in Figure 4. Figure 4 (a) is derived by processing the image using FCM. Segmentation pattern still looks rough. Each image at the contour edges of buildings and other areas is, even so, not clearly visible on form.

![Figure 4](image)

**Figure 4.** Image processing result for Pagelaran district.

To clarify the contours of the edges of the image, then, the analysis of morphological filtering combined into FCM method. Analysis of the top-hat, bot-hat and a combination of both, is used as a method of analysis to strengthen the results of satellite imagery using FCM The use tool strel aimed to clarify the structure of the object contour image, so that the edges of objects to be a segmented image became clear. A disk shape is used to clarify the edges of objects by taking the midpoint of the image as dot-forming discs. To make the structure more detail, use non-negative parameter values by 8. It is because of that, the smaller the value parameter disk is used; the shape of the object image edge structure will be increasingly unclear. The parameter value> 0 will make the operation faster analysis of morphological filtering.

The second stage during the process of segmentation is to connect the FCM with top-hat filtering techniques. This technique is used prior to the FCM analysis. Filtering the results shown in Figure 4(b). The use of top-hat technique can extract the smallest element to the image. The results of image segmentation indicate that the object edges within the image can be detected more clearly than just using FCM only. Top-hat can give the object brightness level higher on the satellite image.

In the next step, the result of image segmentation is done by combining FCM and bot-hat filtering techniques. As with the previous process, bot-hat filtering technique is used prior to analysis by FCM. At this stage, the object in the image that appeared dark conditioned so easy to analyze. The results of image processing on bot-hat technique is not much different when compared with the results of a top-hat filtering. However, there are some objects that escaped from a top-hat and then detected by filtering bot-hat, so the segmentation results using bot-hat shows the results of a more detailed and clearer than the top-hat. The result of the segmentation shown in Figure 4 (c).

The next segmentation techniques are combined the techniques of top-hat and bot-hat filtering. The result from the segmentation shown in Figure 4 (d). The object of the satellite images which have been
segmented very difficult to recognize, why the object on the image is given two handling simultaneously, namely the provision of light from the object (top-hat) so that the brightness level is increasing. The brightness level is increased again after bot-hat techniques are also applied to the object to the image. Background objects and objects from the image tended to appear on segmentation results that make interpretation of the object with the background. Satellite image segmentation followed by lowering non-negative parameter. The parameter values are varied replaced by a value of 2 and 4, and the results can be seen in Figure 5.

![Segmentation result with disk= 2](image1)
![Segmentation result with disk= 4](image2)

**Top-hat filtering**

**Bot-hat filtering**

**The combined top-hat and bot-hat**

Figure 5. Image processing result using non-negative parameter

Differences in the satellite image segmentation results showed a significant difference after lowering the value of a non-negative parameter. Experiments with the value to the parameter = 2, the result from the segmentation can divide very clearly between the observed object in the background object.
Nevertheless, the detail with the object is generated not as the result of segmentation by value parameter $= 4$. Visually, the difference can be observed in Figure 5. The object of observation on a satellite image can be seen clearly, but objects precisely fused with a background object. Background object on the original image is the object of paddy (not a part of observation for this study), but identifiable resemblance gray level equal to building objects. Segmentation results for four other districts also showed similar results. The higher the value of this parameter is given a non-negative, then the level of detail edge detected image of the object more clearly.

6. Conclusion
The results of this study indicate that the use of morphological filtering in general can boost the image of the object contrast. The object image can be clarified using a combination of a top-hat and bot-hat filtering before analyzed using FCM. Despite irregularities in two-sample areas. Object image contrast enhancement is affected by non-negative parameter values given to morphological filtering techniques. The greater the value of the disk is given. The edges of objects detailed segmentation results became clear.

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