New Model of Vegetation Monitoring Using Flying NIR Cameras with NDVI Parameters and C-means

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Abstract. Vegetation is an assemblage of the plant and various constituent flora collectively in a particular region. This research was conducted to test a new model in observing the level of vegetation by using a NIR camera that has an NRG filter, to obtain the NDVI value as the parameter in determining the level of vegetation in a region. The further stage was processing the NDVI value using contrast enhancement and Gaussian smoothing for image enhancement. The results obtained from this stage were clustered using c-means which produced 5 cluster values and the centroid value could be a reference to the value of vegetation in the desired region. Cluster with NDVI value range from -1 to 0.09 showed the value for water and land while the value range above 0.09 showed the cluster for plants.

1. Introduction
Agricultural system in Indonesia, the view of the plant growth process still mostly uses direct/conventional sensing (eyes) in terms of monitoring so that it takes a long processing time. The new model offered by this research utilized NDVI parameter and flying NIR camera. Digital image data that is available on agricultural land or in the forestry sector can facilitate faster vegetation density data collection using NDVI (Normalized Difference Vegetation Index).
NDVI can show parameters related to vegetation parameters, namely biomass of green foliage. The area of green foliage is a value that can determine the division of vegetation in a plant. Researches on NDVI have been carried out in previous research [1]–[4]. Many of these researches used satellite imagery [1], [2] where this satellite image still had cloud pixels in it [2] therefore the use of cameras that utilizing drones was applied in this research to reduce cloud pixels and sharpen the image in smaller plantation areas. In the previous research [3], compared NDVI results using two cameras, and this research concluded that the blue image on NIR camera was the best candidate to be used in NDVI with computation that could be done using a camera with NRG or NGB filters.
NDVI can be grouped automatically by classifying the values exist in NDVI into several vegetation clusters. This classification can be conducted with various algorithms, one of which is a c-means algorithm. This algorithm is a method that uses unsupervised classification. This research is intended to develop a vegetation monitoring system using aerial photography using Near Infrared (NIR) camera with a c-means algorithm to classify NDVI values and the colors on the image results were taken from the classification results, not from the legend colors. The camera used has been modified to become a NIR camera with NRG filter and the results of this research are intended to provide information on the state of vegetation in an environment quickly.

2. Image Enhancement
Image data taken will go to the image enhancement process. The process was carried out in 2 stages, the first step was to sharpen the image contrast in the image using the contrast stretching method, and the next step was noise cleaning using the Gaussian smoothing method. The first image enhancement was contrast enhancement distributed by the grayscale value (gray level) in an image which could be changed so that the values in the image becomes uniform. The equation used in contrast enhancement referred to a previous research[5] using the YCrCb color space.
\[ s = \frac{r - r_{\text{min}}}{r_{\text{max}} - r_{\text{min}}} \times 255 \]  \hspace{1cm} (1)

The second image enhancement was Gaussian smoothing, which was the step to minimize noise arose in the first step by using equation (2) in the reference [6].

\[ G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2 + y^2}{2\sigma^2}} \]  \hspace{1cm} (2)

3. NDVI (Normalized Difference Vegetation Index)

NDVI (Normalized Difference Vegetation Index) is one of the algorithms used to determine the level and distribution of a region’s vegetation index. NDVI is used as an index reference because of its general use for vegetation monitoring [7]. The NDVI formula is stated in equation (3).

\[ \text{NDVI} = \frac{R_{\text{NIR}} - R_{\text{VIS}}}{R_{\text{NIR}} + R_{\text{VIS}}} \]  \hspace{1cm} (3)

In another form, equation (3) can be written into equation (4);

\[ \text{NDVI} = \frac{B - R}{B + R} \]  \hspace{1cm} (4)

The use of the blue channel and red channel was due to the filter changes in the camera. The use of blue channel as the reflectance value of the near-infrared channel (NIR) was because the value in the non-red channel got the NIR reflectance value, while the red channel got the reflectance value from the visible channel. The blue image on the camera that has been modified was the best candidate used as a NIR in NDVI calculation using NRG filter [3]. Blue channel is preferred from the green channel since the blue channel was more representative of the reflectance value of the NIR channel.

NDVI values obtained would be processed and clustered again. The results of the matrix calculation performed would produce basic NDVI where the NDVI values had a value range of -1 (negative) to 1 (positive) [1]. The negative NDVI value showed waters area in the region while the positive NDVI value showed the land area in the region, meanwhile, the land area was represented by the NDVI value that was closest to 0 due to high reflection both from NIR and from the visible image [7].

4. C-means

The c-means method is a method that uses unsupervised classification. This method is a clustering algorithm that is most often used in industrial applications and machine learning. This method classifies objects based on attributes into divider of c. The purpose of this method is to determine c. The data used in a cluster is obtained by comparing distance. Euclidean distance is a method used to calculate the similarity of two vectors. This Euclidean distance formula is stated in equation (5)

\[ C = \min \sum_{x \in C_j} \| x - \mu_j \| \]  \hspace{1cm} (5)

Where \( C_j \) is cluster j, x is the data in cluster j and \( \mu_j \) is the centroid of cluster j [8].

5. Research Methodology

Methodology in this research was typically the process of noise cleaning and image contrast sharpening of digital images captured by the camera, and this process is often called an image enhancement technique. This technique was conducted by two methods, namely Gaussian smoothing method and contrast enhancement method. After image enhancement, the NDVI calculation process was the next step. The process of calculating the NDVI image color that was originally 24 bits would change to NDVI image that had a value of -1 to 1, then the image changes were performed using c-Means and changing...
the NDVI image into several classifications. The color classification was carried out using the c-means method that used five clusters. Each cluster was divided into different colors, and the five clusters would display centroids and the number of members of the existing pixel. The methodology stages in this research can be seen in the flowchart in Figure 1.

![Flowchart](image)

**Figure 1.** Flowchart on how the system works.

6. **Result and Discussion**

The image enhancement processes performed in this research were contrasted enhancement and Gaussian smoothing which was intended to produce a better quality to be processed in the next stage. The results of the contrast enhancement can be seen in Figure 2.

![Contrast enhancement image results](image)

**Figure 2.** Contrast enhancement image results.

![Gaussian smoothing image results](image)

**Figure 3.** Gaussian smoothing image results.
The results of the Gaussian smoothing at this stage of the enhancement image have several multiplier matrices that can be selected, where the images using different matrix multipliers can be seen in Figure 3.

Different multiplier matrix will be tested on systems from multiplier matrix using Gaussian 3x3 to multiplier matrix using Gaussian 9x9 which can be seen in Figure 4. Different results were obtained from the final output of clustering results using the c-means method.

![Figure 4. Gaussian smoothing image result using c-means.](image)

![Figure 5. NDVI value range.](image)

![Figure 6. Maximum and minimum NDVI values.](image)

NDVI data range in Figure 5 was taken from the maximum and minimum values in Figure 3. Figure 5 is the cluster results showing that the larger the matrix multiplier applied, the greater the NDVI range, the 9x9 Gaussian had the farthest range value. Figure 4 shows the different results and 7x7 Gaussian and 9x9 Gaussian showed the best clustering results using c-means. The Gaussian smoothing in this research utilized 9x9 Gaussian multiplier matrix since 9x9 Gaussian had the furthest range and good
clustering. However, the certainty of using Gaussian smoothing must consider the tradeoff of a computation that determines the accuracy and precision of an image analysis that can be calculated by the computing device architecture [9].

Figure 6 is the result of maximum and minimum pixel values from various image samples. Image samples taken had different characteristics, namely sample 1 was an image of vegetation with a part of arid land, the second sample was an image of road, the third sample was an image of river, the fourth sample was an image of vegetation between buildings and the fifth sample was an image of vegetation with land arid. Those samples were taken to prove whether the NDVI value in the image had a maximum value of 1 and a minimum of -1, 1 and -1 were the maximum and minimum NDVI values[7]. Those values proved that equation (4) for NDVI calculation performed on the system was the correct equation, with no value that exceeded the NDVI values. The third image which was the image of water in table 1 had the lowest cluster range, where -0.63 indicated that the water cluster had a negative value. Only active vegetation had positive NDVI.

**Table 1. Centroid value of each cluster.**

| Picture     | Centroid Value |
|-------------|----------------|
|             | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 |
| Sample NIR 1 | -0.0905  | 0.0654    | 0.2017    | 0.3499    | 0.9503    |
| Sample NIR 2 | -0.0798  | 0.0447    | 0.3742    | 0.6384    | 0.9       |
| Sample NIR 3 | -0.6364  | -0.3156   | -0.1286   | -0.0443   | 0.0759    |
| Sample NIR 4 | -0.043   | 0.0695    | 0.1533    | 0.3149    | 0.6475    |
| Sample NIR 5 | -0.0376  | 0.0471    | 0.1286    | 0.2361    | 0.6429    |

Clustering results using c-means applied a variety of different data to generate cluster values which can be seen in Table 1 as the centroid of the certain cluster and Table 2 shows the number of pixels in a cluster.

**Table 2. The number of memberships for each cluster.**

| Picture     | Memberships of each cluster |
|-------------|-----------------------------|
|             | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 |
| Sample NIR 1 | 9005      | 5249      | 674       | 65        | 7         |
| Sample NIR 2 | 7838      | 7150      | 7         | 3         | 2         |
| Sample NIR 3 | 2059      | 2074      | 6536      | 2781      | 1551      |
| Sample NIR 4 | 11161     | 3059      | 756       | 22        | 2         |
| Sample NIR 5 | 10302     | 1817      | 2753      | 127       | 1         |

**Figure 7. Group of NDVI value**

Based on the results of clustering using c-means in table 2, each cluster showed different results, these results were adjusted to the values that existed in the image because of different centroid values.
Clustering results obtained in the waters area had the lowest value of -1 up to -0.1 while the value of -0.1 up to 0.09 showed cloud, land and road area, for the value above 0.09 showed the plant vegetation area. These data can be seen in Figure 7.

7. Conclusion
This research performed image enhancement so as to obtain uniform grayscale values distribution from the data processed in the image to minimize the noise. Table 1 proved that none of the values exceeded the maximum value and the minimum value in NDVI. Clustering results for water vegetation had a negative value while the clustering for plant vegetation showed a value of more than 0.09. The types of clusters could not be specified, but they could be seen based on the centroid values because each image had a different vegetation value. The data in NDVI that existed in each data cluster could be information for future research.

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