

Comparison of LoG (Laplacian of Gaussians) and DoG (Difference of Gaussians) Algorithms in the Measurement of the Nerve Quality Level of Gotu Gotu Leaves.

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Abstract

Gotu gotu leaves (*Centella asiatica*) are herbal plants with high pharmacological benefits thanks to the content of active compounds such as asiaticoside, madecassoside, and asiatic acid. The pharmacological quality of these leaves is greatly influenced by the condition of their neural networks. This study aims to compare two popular edge detection algorithms, namely Laplacian of Gaussian (LoG) and Difference of Gaussian (DoG), in measuring the level of nerve quality of the leaves of the peg. The method used is Python-based digital image processing with OpenCV, using primary data in the form of gotu tu leaf images in JPEG, PNG, and JPG formats. The results showed that the DoG algorithm was more efficient in computational time and was able to produce sharper leaf neural images, while LoG excelled at detecting the main line but tended to generate over-detection. Thus, the DoG is more suitable for the implementation of an automated system for assessing the quality of gotu gotu leaves in agriculture and pharmaceuticals.

Keywords: *Centella asiatica*; Digital Image Processing; Edge Detection; Laplacian of Gaussian; Difference of Gaussian

1. Introduction

Gotu gotu leaves (*Centella asiatica*) are medicinal plants of high economic and medical value because of the content of active compounds such as asiaticoside, madecassoside, and asiatic acid which have antioxidant, anti-inflammatory, and neuroprotective activities [1]. Demand for medicinal plants continues to increase by about 12% per year, with gotu gotu among the top ten most potential crops [2].

The pharmacological quality of gotu gotu is greatly influenced by the condition of the leaf's nerve tissue which plays a role in the distribution of nutrients and metabolites. Manual assessment of leaf nerve quality is subjective and inconsistent, so a more objective approach is needed [3].

Digital image processing offers a systematic solution for automatically assessing leaf morphology. Previous research has shown this method to be effective in the classification of medicinal plants with high accuracy [4]. One of the key techniques is edge detection, which can be done using the **Laplacian of Gaussian (LoG)** and **Difference of Gaussian (DoG)** algorithms. LoG combines smoothing with edge detection, while DoG uses a two-Gaussian difference to detect changes in intensity [5].

Although both have been widely used, research comparing LoG and DoG on gotu gotu leaves is still limited [6]. Therefore, this study aims to compare the effectiveness of the two algorithms in detecting the neural quality of the leaves of the pegagan, so that it can support the development of digital-based quality assessment methods in the agricultural and pharmaceutical sectors.

2. Related Works and Theoretical Background

2.1 Previous Studies

Several previous studies have discussed the application of edge detection algorithms to analyze leaf structure. The Sobel, Prewitt, and Canny methods are often used. Research by Manik et al. showed that the Sobel method was able to detect the edges of the mango leaf image well, but the results were less subtle than other methods [7]. Meanwhile, Kurniawan et al. proved that the Canny method can produce more detailed and fine edge detection on shallot leaf imagery [8].

Although research on edge detection in various types of leaves has been carried out, special studies comparing **the Laplacian of Gaussian (LoG)** and **Difference of Gaussian (DoG) algorithms** in the context of gotu gotu leaves (*Centella asiatica*) are still rare. This opens up research opportunities to find out which algorithm is more effective in accurately detecting the neural patterns of gotu tu leaves.

2.2 Digital Image Processing

Digital image processing is a visual data processing technique that is converted into numerical form so that it can be analyzed by a computer. This process generally includes five stages:

1. Akuisisi citra (image acquisition)
2. Pra-pemrosesan (grayscale conversion, filtering, noise reduction)
3. Segmentation (selection of objects from the background)
4. Feature extraction
5. Classification [9]

In this study, the main focus stage is **segmentation** using LoG and DoG edge detection algorithms to extract the nerve patterns of the leaves of the peg.

2.3 Laplacian of Gaussian (LoG)

LoG is an edge detection method that works on the principle of **zero-crossing**, which detects changes in image intensity after noise reduction using Gaussian blur. The LoG kernel produces images with high edge sharpness, but its weakness is that it is prone to **over-detection**, which detects too many edge lines, including noise [10].

2.4 Difference of Gaussian (DoG)

DoG is a simplification of LoG. This algorithm uses the difference between two Gaussian blurs with different standard deviations to highlight the change in intensity in the image. The advantage of DoG is that it is computationally faster than LoG, but it is still accurate in detecting fine patterns such as leaf nerves [11].

2.5 Gotu Kola (*Centella asiatica*)

Gotu gotu (*Centella asiatica*) is a medicinal plant with a kidney-shaped leaf morphology and a finger nerve pattern. The content of its active compounds, such as asiaticoside, madecassoside, and asiatic acid, is mostly found in leaf tissue. Therefore, the quality of leaf nerves is closely related to their pharmacological effectiveness [3]. Assessment of the nerve quality of gotu gotu leaves with digital technology is important as part of the quality control of herbal raw materials.

3. Research Method

3.1. Research Methods

The research method is a series of steps that are systematically arranged so that the research can run in a directional direction and the expected goals are achieved. This method includes structured procedures ranging from planning, implementation, to research analysis. In the process of solving problems, there are several stages of research that must be taken. These stages can be explained as follows:

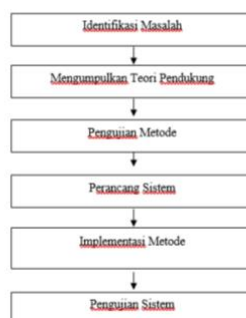


Fig. 1 : Metodologi penelitian

The stages of this research include:

1. Problem identification and literature study.

2. Collection of data on leaf imagery.
3. Pre-processing (grayscale, normalization, noise reduction).
4. The application of LoG and DoG algorithms uses Python–OpenCV.
5. Analysis of detection results based on clarity of neural structure and computational time.

3.2 Data Collection

The data used were images of gotu tu gotu leaves (*Centella asiatica*) obtained from direct documentation using a high-resolution digital camera. The dataset consists of dozens of images of healthy leaves with various lighting conditions. The image file formats used are **JPEG, JPG, and PNG** to be compatible with Python-based image processing software [3].

3.3 Image Preprocessing

Image pre-processing aims to improve visual quality before edge detection. The stages used are:

1. **Grayscale conversion:** converts color imagery to gray imagery to reduce computational complexity.
2. **Gaussian filtering:** reduces noise that can affect edge detection results.
3. **Normalization:** standardizing image sizes for more consistent detection results.

3.4 Implementation of LoG Algorithm

The **Laplacian of Gaussian (LoG)** method is applied in stages:

1. Blur the image with Gaussian blur to reduce noise.
2. Apply the Laplacian operator to the blurred image.
3. Detects edges based on the principle of **zero-crossing**, i.e. a significant change in pixel intensity.

Mathematically, the LoG kernel can be written as:

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

3.5 Implementation of DoG Algorithm

The **Difference of Gaussian (DoG) algorithm** is applied by calculating the difference of two Gaussian blur results with different standard deviations. The DoG formula is defined as:

G kecil (σ kecil) : Gaussian kernel klasik

$$\frac{1}{16} \cdot \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

G besar (σ besar) : Gaussian rata – rata 3 x 3 biasa (semua 1/9)

$$\text{DoG} = \text{G } \sigma_{\text{kecil}} - \text{G } \sigma_{\text{besar}}$$

3.6 Tools and Environment

This study uses **Python** software with **OpenCV** and **NumPy libraries** as the main image processing tool. The analysis was carried out on computers with specifications: Intel Core i5 processor, 8 GB of RAM, and Windows 10 operating system.

4. Results and Discussion

4.1 Experimental Results

Tests were conducted on 30 gotu tu tu gugu leaf images in JPEG, PNG, and JPG formats using Python-OpenCV. The implementation of LoG and DoG algorithms produces outputs in the form of nerve images of the leaves that have been detected.

Table 1 shows the average comparison of test results between the **LoG** and **DoG** algorithms.

Table 1. Comparison of LoG and DoG Results

Parameter	LoG	DoG
Waktu komputasi (detik)	0.214 s	0.135 s
Noise detection	Tinggi (over-detection)	Rendah (minim noise)
Ketajaman saraf daun	Sedang	Tinggi
Garis utama saraf	Jelas	Jelas

Parameter	Log	Dog
Compute time (sec)	0.214 s	0.135 s
Noise detection	Tinggi (over-detection)	Low (minimal noise)
Nerve acuity of the leaves	Keep	Tall
Main lines of nerves	Clear	Clear
Fine nerve details	Less detectable	Detected well

Figure 4.1 shows an example of an image of edge detection using both algorithms.

1. **LoG**: displays the main nerve lines clearly, but there are many additional lines due to noise.
2. **DoG**: produces sharper neural images, with fine details detected and less noise.

4.2 Discussion

Based on the test results, DoG is proven to be superior to LoG in the aspect:

1. **Compute time efficiency** – DoG is faster $\pm 37\%$ than LoG, making it more suitable for real-time automated systems.
2. **Visual quality of nerve detection** – DoG displays a more refined leaf neural structure, while LoG tends to detect over-detection.
3. **Implementation suitability** – LoG is suitable for analysis of the main structure of leaves, while DoG is more suitable for detailed evaluation of nerve quality.

These results support the research of Syam et al. [6] which emphasizes the importance of selecting edge detection methods in leaf image processing. Thus, **DoG is more recommended** as the main algorithm in digital-based gotu gotu leaf nerve quality assessment systems in the agriculture and pharmaceutical sectors.

5. Conclusions and Suggestions

5.1. Conclusion

This study compares the **Laplacian of Gaussian (LoG)** and **Difference of Gaussian (DoG) algorithms** in the detection of the nerve edges of the leaves of the leaves. The results show that:

1. **LoG** excels in detection acuity and accuracy in leaf veins, yet is sensitive to noise.
2. **DoG** is more computationally efficient and able to reduce noise, although the sharpness is lower.
3. The system successfully classified the quality of gotu leaves into **good, medium, and poor categories** based on the distribution of nerve edges.

Thus, **LoG** is more appropriate for detailed analysis, while **DoG** is more suitable for fast processing of large amounts of data.

5.2 Suggestions

For further development, it is recommended that:

1. Using a more diverse leaf dataset.
2. Compare with other algorithms such as **Canny** or **Sobel**.

3. Integrate the system with **machine learning/deep learning**.
4. Develop web/**mobile-based applications** to make them more practical.
5. Testing the system with various field conditions (lighting, camera, leaf conditions).

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