2022 International Conference on Innovation and Intelligence for Informatics, Computing, and Technologies (3ICT) | 978-1-6654-5193-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/3ICT56508.2022.9990758

# Detection of Lettuce Plant Conditions Based on Images using Backpropagation Method

Hanizar Rachman
School of Electrical Engineering
Telkom University
Bandung, Indonesia
hanizarchmn@student.telkomuniversity.ac.id

Yudha Purwanto
School of Electrical Engineering
Telkom University
Bandung, Indonesia
omyudha@telkomuniversity.ac.id

Casi Setianingsih
School of Electrical Engineering
Telkom University
Bandung, Indonesia
setiacasie@telkomuniversity.ac.id

*Abstract*— **In cultivating different ways should be possible, one of which is utilizing the aquaculture strategy. Lettuce is remembered for plants that can be developed utilizing this strategy. Produce great lettuce, it deals with and great plant the executives. Direct observing requires a ton of energy and takes a great deal of time since you need to really look at the state of the plants individually. With these issues, a framework was intended to distinguish the state of the lettuce leaves involving a camera as a picture catch instrument. This exploration planned to make a work area based framework for recognizing the state of lettuce utilizing the Backpropagation characterization strategy. The states of lettuce plants are separated into two classes in view of lettuce leaves with sound green tips, and lettuce leaves with less great leaf tips with yellow tone and earthy colored spots. Identification of lettuce plant conditions utilizing pictures taken with a Raspberry-pi camera. The consequence of this exploration is the framework can identify sound leaf condition class and leaf condition class with yellow tone and earthy colored spots. The result of the framework is as class names and likelihood values from the order results. With a parameter in the form of a training data partition of 90% and 10% test data, the accuracy rate is 98%.**

***Keywords: Hydroponics, Expert-based, application***

## I. INTRODUCTION

Nowadays, technology is developing very rapidly. These technological developments can be used to meet various needs and help all community activities. One of the activities that can take advantage of current technology is farming using hydroponic techniques. The hydroponic technique itself has been developed into the Internet of Things as a means to make it easier to monitor plants.

Previous research has been carried out for the Internet of Things system. By using a device such as a microcontroller such as the Raspberry pi combined with other input and output devices, monitoring of hydroponic plant growth can be controlled remotely by farmers using devices such as smartphones [1]. However, the disadvantage of the system that has been built is that it does not have a monitoring system using a camera that aims to see the condition of the plants themselves. Therefore, making a system that can assist users in cultivating and maintaining hydroponics by monitoring plant growth to make it more efficient, so that farmers do not need to put a lot of effort into monitoring one by one directly the plants being planted because it does not require much time.

In a system built to monitor whether the condition of lettuce plants is good or not. Therefore, the camera is used as a tool to monitor the condition of these plants. The monitoring process will be carried out by taking pictures that will then be processed through image processing using the Backpropagation method based on the parameters of the plant to determine the condition of the lettuce plant.

## II. RELATED WORK

An automated plant growth monitoring system has been implemented previously. This work joins Picture Handling and IoT to screen processing plants and gather ecological factors like moistness and temperature. In picture handling, an acknowledgment framework has been fostered that can recognize plants utilizing the picture of their leaves, and with the assistance of these pictures, the utilization of pesticides can be controlled. It's just that this system still uses conventional image processing methods without involving machine learning [2].

This paper aims to detect plant growth in on-line computer systems. Nine pictures of cucumber plants were taken via videocon camera from various angles. The cropped image is digitized to 256x256 size by continuously adjusting the brightness level of the cropped crop. Next, the digital image is read into the CPU and stored in disk memory. With plant image processing, growth is represented quantitatively and statistical pattern recognition. This makes it possible to estimate differences in growth characteristics [3].

## III. RESEARCH METHOD

### A. Hydroponics

Hydroponics is a farming technique that has various advantages when compared to conventional farming techniques. The advantage of hydroponic cultivation is that it does not require a large area of land so it can be applied by urban communities with limited vacant land availability. The choice of plant types that can be planted varies with faster growth rates so that they are harvested more quickly [4]. Hydroponics is also a means of channeling a hobby of farming and also a model of farming that does not require soil as a growing medium for these plants.

### B. Lettuce

Lettuce (Lactuca sativa L.) is a plant species of the Asteraceae family. These plants can be classified based on the morphology of fleshy leaves, with seven types recognized by the International Code of Nomenclature for cultivated plants. The classification of lettuce is based on differences in size and shape, and fewer leaves on pigmentation (Ryder 1999) [5]. Lettuce plants grow with leaves that are larger than the stems as in other plants. Where almost all parts can be eaten and can be used as a complement to foods such as burgers.

### C. Artificial Neural Networks

Artificial Neural Networks can also be called neural networks inspired by the biological system of nerve cells in the human brain [6]. It is believed that the human brain nerve cells are estimated to have 100 billion nerve cells [7]. With inspiration from nerve cells in the human brain, an Artificial Neural Network (ANN) can be formed which can mimic the workings of the human brain, such as the dendrites in which neurons can receive signals from one another. From this, it can be used as a model as input to the Artificial Neural Network model. Then the input can be passed as output as in axon [7].

### D. Histogram of Oriented Gradients

HOG is a feature extraction that is used on image objects. It can describe an image with a gradient density distribution. Before entering the feature extraction process, the image must first be converted into a grayscale image. A grayscale image is an image that only has a channel value for each pixel. The colors contained in the grayscale are black, gray, and white. Grayscale images have an 8-bit color depth [8]. To change an image that has an RGB color to grayscale [9], use the following calculations:

$$grayscale = 0.299R + 0.587G + 0.114B \tag{1}$$

After it is converted into a grayscale image, then enter the HOG process. This HOG method uses 4 steps to extract the object. The first step is to calculate the gradient value by applying a single filter for the horizontal and vertical directions [9]. The formula for calculating the gradient value is as follows:

$$D_x = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix} \quad D_y = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} \tag{2}$$

If the object of the image is I, then the derivative of x and y is obtained using a convolution operation:

$$I_x = I_x * D_x \text{ and } I_y = I_y * D_y \tag{3}$$

To calculate the magnitude of the gradient, use the equation:

$$|G| = \sqrt{I_x^2 + I_y^2} \tag{4}$$

To find the orientation of the gradient [10]value, use the formula:

$$\theta = \arctan\frac{I_y}{I_x} \tag{5}$$

The second step the partial orientation binning. Forming a histogram requires a gradient value and the value of each pixel in an image. Then the image is divided into cells with the size to be determined. The third stage is the normalization of cells and histograms from all block regions to become vectors. The fourth stage or the last stage is block normalization using L2-norm with equations:

$$b = \frac{b}{\sqrt{\|b\|^2 + \varepsilon^2}} \tag{6}$$

### E. Backpropagation

The backpropagation algorithm was first discovered in 1970 as an optimization method for the automatic differentiation of complex nested functions. In 1986, published a paper by Rumelhart, Hinton, and Williams, this algorithm became popular and is often used, especially in neural networks [9].

This technique is one kind of preparing strategy that is delegated supervised learning. Backpropagation requires an objective as a kind of perspective in the preparation cycle, where the proliferation objective is set so it has a more modest mistake esteem in an organization, or it very well may be called getting a result esteem that is near the ideal objective. The consequence of this preparing is a bunch of weight esteems, these weight values address information on the growing experience that has been done [10]. A few things are realized in an organization including weight, predisposition, and enactment capabilities. Loads are helpful data for taking care of explicit issues. Predisposition is a worth that can work on the presentation of the brain network which has an initiation worth of consistently 1. The initiation capability is expected to work out the result reaction of the brain network hub.

## IV. SYSTEM DESIGN AND OVERVIEW

### A. SYSTEM DESIGN

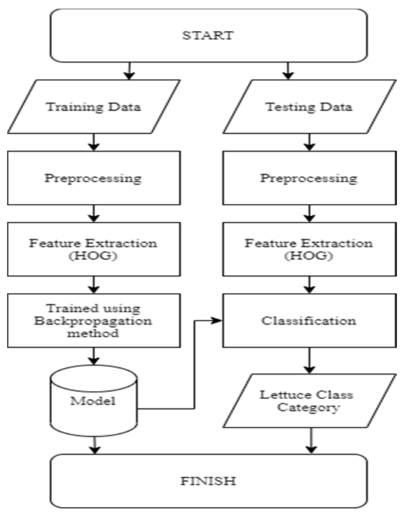


Fig. 1. Flowchart System

Fig. 1 outlines the image processing process that will be carried out by the lettuce plant condition detection application to divide the dataset into training data and testing data, preprocessing, training using the backpropagation method, and producing output in the form of class label lettuce classification results.

## B. Image Acquisition


Fig. 2. Each Lettuce Image from Class A, and Class B

Fig. 2 shows the acquisition of the lettuce plant itself was taken in the 2nd and 3rd weeks after the plants were transferred from the seedling process to the hydroponic planting medium. The number of plants in the hydroponic growing media is 9, and for the dataset, 4 lettuce plants can be captured on camera with a resolution of 2592 x 1944 pixels in JPG format. Here's one of the images the camera can capture.

The number of lettuce plants is divided into 2 classes (Fig. 3), Class A is taken from the image that is cropped manually on the right side of the image, and Class B is taken in the middle of the image.


Fig. 3. Patches from Lettuce Image from each Class

The amount of data set use in this system is 300. Figure 3 shows the results of the lettuce photo that has been cut.

## C. Training Process

### 1) Preprocessing

In this process, the a x b pixel lettuce image is converted to a 60x60 pixel size. The resizing process is done to generalize the image size and speed up the computation process during classification.

### 2) Feature Extraction

After getting the pre-processing results then go into the feature extraction process (Fig. 4). Feature extraction will be carried out starting from the first stage, namely calculating the gradient value. The results of the gradient values will be carried out by spatial orientation binning. Reunite the pixels by normalizing cells and after that do the block normalization. The results of this stage of the process will be an array of feature extraction results.

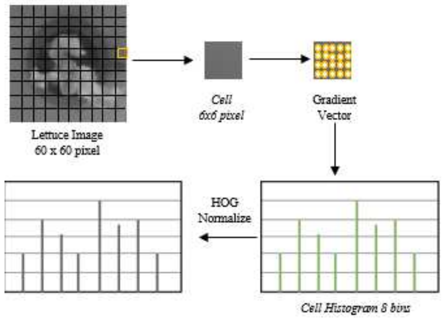


Fig. 4. Step-by-step Feature Extraction

### 3) Training

At this stage (Fig. 5), the results of the feature extraction process using HOG will become input data in the classification process using the backpropagation method to form a model. This process uses the sci-kit-learn library. The library used is called MLPClassifier. This library is capable to conduct training to create models that we can use later to make class predictions of lettuce plant conditions.

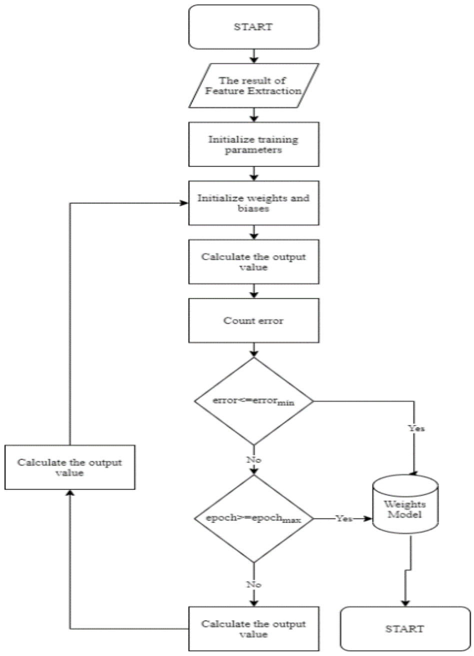


Fig. 5. Flowchart Backpropagation

# V. RESULT

## A. System Implementation

The interface of the application is designed using the PyQt5 library and the Python programming language version 3.6.5. The application was built to facilitate users in the classification process of lettuce plant conditions.

If seen from the image above, the application has buttons for selecting images that are already available in the computer folder and can perform the prediction process. The following is an implementation of the application interface design:

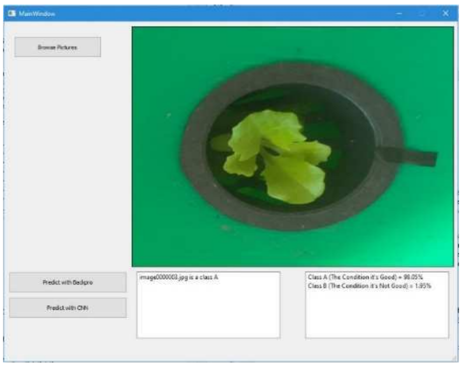

Fig. 6. Detection Result

B. Data Partition Testing

The partition data used is 300 images which are partitioned into training data and test data by 90% training, 80% training, 70% training, 60% training, and 50% training. With a learning rate of 0.1 and an epoch of 200.

TABLE I. DATA PARTITION TESTING

| Testing Data (%) | Training Data (%) | Learning Rate | Epoch | Accuracy (%) |
|---|---|---|---|---|
| **10** | 90 | 0.1 | 200 | 100% |
| **20** | 80 | | | 80% |
| **30** | 70 | | | 73% |
| **40** | 60 | | | 75% |
| **50** | 50 | | | 76% |

The results show in Table I that the best accuracy is obtained by partitioning 90% of the data as training data and 10% as test data with an accuracy of 100%. From the results of this data partition testing, it can be concluded that the more training data carried out in the training process, the results have better the probability value. Because the pattern of information obtained is increasing and it will make this system perform the classification process very well. So, in further testing, the data partition used is a comparison of 90% training data and 10% test data.

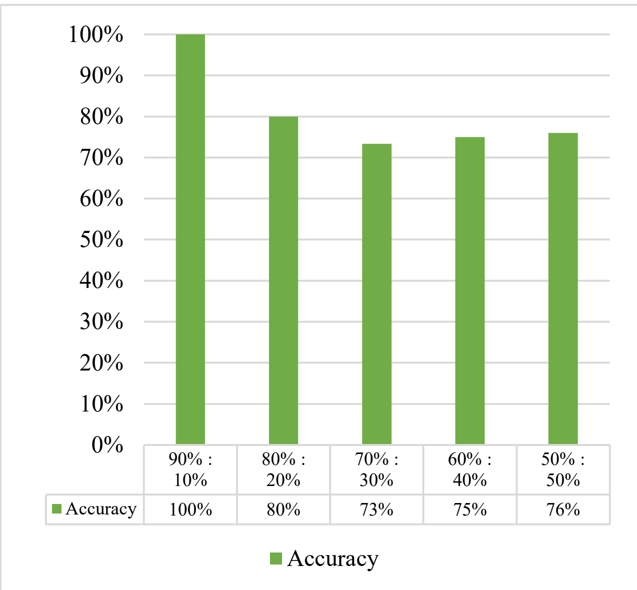


Fig. 6. Result of Partition Data

C. Learning Rate Testing

Table 2 are the results of the learning rate test which are summarized in the table below:

TABLE II. LEARNING RATE TESTING

| Leaning Rate | Epoch | Accuracy (%) |
|---|---|---|
| 0.1 | 200 | 100 |
| 0.01 | | 100 |
| 0.001 | | 100 |
| 0.0001 | | 83.3 |

The results of this learning rate experiment in Table 2 and Fig. 8 show that the best accuracy uses a learning rate of 0.1 with 100% accuracy. This is because the smaller the learning rate, the greater the accuracy to reduce the error value in the system. However, this must be proportional to the number of epochs or iterations because it is convergent, the learning process will take longer and require a larger epoch. A learning rate of 0.0001 can reach 100% accuracy if 1000 epoch is used. So, with the experiments that have been done, the learning rate used is 0.1 for the next experiment.

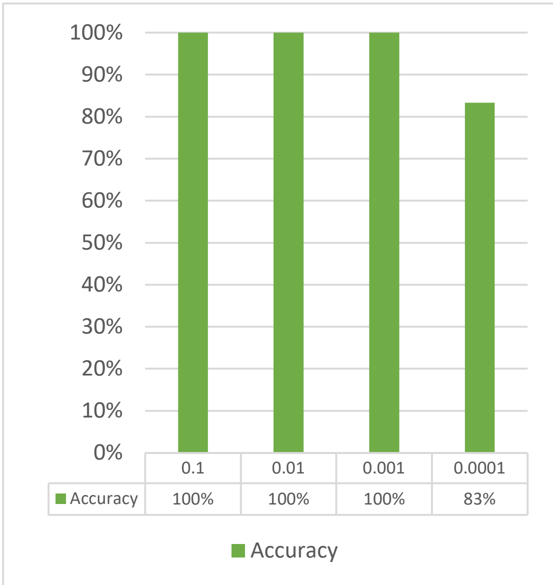


Fig. 7. Result of Learning Rate

D. Epoch Testing

From the results of the epoch test it can be seen in the following table:

TABLE III. EPOCH TESTING

| Epoch | Training Accuracy(%) | Testing Accuracy(%) |
|---|---|---|
| 1 | 92.96% | 67.67% |
| 2 | 92.96% | 83.33% |
| 4 | 100% | 83.33% |
| 8 | 100% | 100% |
| 16 | 100% | 100% |

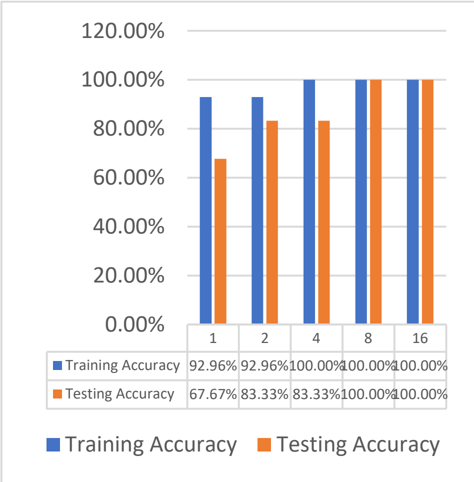


Fig. 8. Result of Epoch

The results of epoch testing in Table III and Fig. 9 show the best accuracy obtained. It can be concluded that epoch affects the learning process to reduce the error value in the system which causes increased accuracy. Epoch has a saturation point where if it reaches the highest accuracy, accuracy tends to remain.

## VI. CONCLUSION

Based on this research, it can be concluded that the system that has been designed is as follows:

1. The condition detection system for lettuce plants can be classified into 2 classes, namely leaves with healthy green leaf tips, and leaves with unhealthy leaf tips in the form of yellow and brown spots well.
2. Using images that are available in-store with training data partitions of 90%, test data of 10%, the learning rate of 0.1, and the number of iterations or epochs of 8, the system can classify with an accuracy rate of 98%.

## REFERENCES

[1] Lakshmi, K., & Gayathri, S. (2017). Implementation of IoT w ith image processing in plant growth monitoring system. Journal of Scientific and Innovative Research, 6(2), 80-83.
[2] Eguchi, H., & Matsui, T. (1977). Computer Control of Plant Growth by Image Processing II. Pattern Recognition of Growth in On-line System. Environment Control in Biology, 15(2), 37-45.
[3] C. J. G. Aliac and E. Maravillas, "IOT hydroponics management system," 2018 IEEE 10th Int. Conf. Humanoid, Nanotechnology, Inf. Technol. Commun. Control. Environ. Manag. HNICEM 2018, pp. 1–5, 2019.
[4] M. Iqbal, Simpel Hidroponik, I. Andi Offset, 2017.
[5] M. R. Davey, P. Anthony, P. Van Hooff, J. B. Power, and K. C. Lowe, "III . 4 Lettuce," Biotechnol. Agric. For., vol. 59, pp. 221–249, 2007.
[6] S. s. T.Sutoyo, Teori Pengolahan Citra Digital. Yogyakarta: C.V ANDI OFFSET, 2009.
[7] J. Shirahatti, R. Patil, and P. Akulwar, "A Survey Paper on Plant Disease Identification Using Machine Learning Approach," Proc. 3rd Int. Conf. Commun. Electron. Syst. ICCES 2018, no. Icces, pp. 1171–1174, 2018.
[8] A. Pamungkas, "Pengolahan Citra." [Online]. Available: https://pemrogramanmatlab.com/pengolahan-citra-digital/. [Accessed: 28-Jul-2020].
[9] B. Sugiarto et al., "Wood identification based on histogram of oriented gradient (HOG) feature and support vector machine (SVM) classifier," Proc. - 2017 2nd Int. Conf. Inf. Technol. Inf. Syst. Electr. Eng. ICITISEE 2017, vol. 2018-Janua, pp. 337–341, 2018.
[10] M. I. Taqyudin, B. Irawan, and C. Setianingsih, "Wood Classification Based on Fiber Texture Using Backpropagation Method," ICSECC 2019 - Int. Conf. Sustain. Eng. Creat. Comput. New Idea, New Innov. Proc., pp. 245–250, 2019.