Detection of Corn Leaves Nutrient Deficiency Using Support Vector Machine (SVM)

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***Abstract*- Like other plants in general, corns are also requiring nutrients for their life. Nitrogen, phosphorus, and potassium are at least three main nutrients that all plants always need except corn. There are so many methods that can use to examine these three nutrients for corn through its leaves such as Leaf Color Chart (LCC), Chlorophyll Meters Soil Plant Analysis Development (SPAD), and Soil Test Kit. One method that is mostly used by farmers to examine nutrients content through corn leaves is used Leaf Color Chart (LCC) because it cost less than the other two. To overcome this problem, digital image processing could be a good solution that can be adopted by farmers to examine their plant's nutrients needs in an easier and cheaper way. In this study, the RGB extraction method of Hue, Saturation, Value (HSV) is proposed for a digital image processing system for corn leaves images. To classified its images result, Support Vector Machine (SVM) is used as a classification method for this study. By using this proposed method, an accuracy value of 80% is achieved to detect nutrients content in corn leaves.**

Keywords - agriculture, corn, nutrients, digital image processing, svm, machine learning

I. INTRODUCTION

Corn is ranked second as the most widely grown food crop in Indonesia. According to data from the Ministry of Agriculture, from 2010 to 2014 there was an increase in productivity of up to 2.67% per year, although the area of harvested land decreased by about -1.77% [1]. Therefore, qualified agricultural technology is needed to maintain, or even increase, the productivity of corn farmers and promote corn products as a commodity itself. One of the main problems in agriculture is the plant's need for nutrients. It is like a daily food that keeps plants alive and healthy so that they can become superior and quality agricultural products.

At least, there are three main nutrients needed by plants, including corn, namely nitrogen (N), phosphorus (P), and potassium (K). One way to see plant nutrient requirements is to observe the physical condition of the plant itself. In corn, the symptoms of phosphorus deficiency can be seen when the plant is still young (not knee-deep), in the form of dark leaf edges. As for potassium, symptoms of deficiency can be observed from the time the plants are knee-high until after flowering, where the old leaves are curly, causing brownish red spots, until then dry and die [2].

A lot of study related to digital image processing has been carried out by many researchers using various methods [3]–[5]. Most of research was conducted using various image classification methods such as Convolutional Neural Network (CNN), Naïve Bayes Classifier, K-Nearest Neighbor (K-NN), Fuzzy Logic, Support Vector Machine (SVM), etc. Every research related to digital image processing is carried out through several stages such as image data collection, image preprocessing, image feature extraction and application of classification methods. Based on that previous study, these stages could be applied in study that aims to detect corn plant nutrients based on its leaves color. Based on these stages result, a new technology can be developed as solution for farmers to increase corns nutrition according to its need.

Leena et al. has conducted a study that compared several classification methods of corn plants using GLCM and Histogram as feature extraction methods. The results showed that the KNN method got an accuracy value compared to SVM and ANN. Other study conducted by Hongfei Zhu et al. that use Support Vector Machine (SVM) to sort the quality of carrot plants through digital image processing, showing an average accuracy of more than 97%. This research combines the SVM classification model with deep feature digital image extraction data using a convolutional neural network (CNN).

Based on both studies, contribution of this study is used SVM method with HSV as extraction feature to examine nutrition content of corn plant using its image. Corn leaves image are collected using smartphone from Padang Raya Village, Balangan District, South of Kalimantan. After several stage such as image pre-processing, converting into RGB value and extracting it into HSV value, data will be classify using SVM method to get its accuracy value. Section 2 of this paper will be described review of related study. In section 3, research methodology that used for this study will be escribed step by step. Result and conclusion of this study will be explained in section 4 and 5 respectively.

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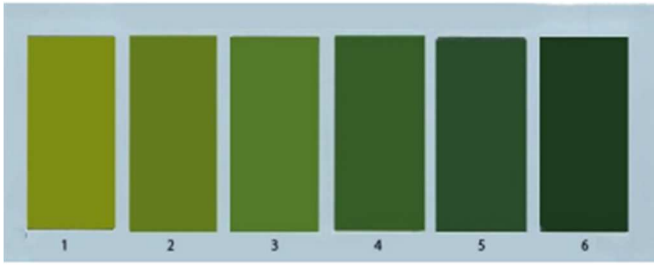

Fig. 1. Leaf Color Chart

II. Literature Review

Several studies have been conducted related to digital image processing with various different methods for both feature extraction and classification. The research was conducted in different fields, one of which is agriculture with the aim of helping farmers to increase the quantity and quality of harvests.

Research on plants was also conducted by Hongfei Zhu et al. using the Support Vector Machine (SVM) method which aims to classify the quality of carrot plants based on the results of image processing. This study combines the SVM method with a deep feature digital image extraction data using a convolutional neural network (CNN) which obtains an accuracy value of 97% [6].

Leena et.al conducted research that made corn as an object in 2018 using several classification methods, namely K-Nearest Neighbor, Artificial Neural Network (ANN) and Support Vector Machine (SVM). This comparison was conducted to determine the most accurate classification method used for the image of corn plants that had been extracted using GLCM and Histogram. From the results of this study, it is known that KNN has the highest accuracy value compared to the other two methods in classifying image extraction with GLCM and Histogram [7].

Several studies related to agriculture have been carried out by several researchers on different types of plants. In 2020, Sari et al. conducting research on rice plants which aims to determine the right dose of fertilizer based on the results of rice image classification. Classification with fuzzy logic method is carried out on rice images that have been extracted using the Hue Saturation Value (HSV) method which obtains an accuracy of 90% [8].

DelaO-Arevalo et al. also conducted research in 2019 which aimed to compare several classification methods to Meibography images. Of the 4 classification methods, namely Probabilistic Maps (PM), Convolutional Neural Networks (CNN), Random Forests (RF) and Support Vector Machine (SVM), it was found that SVM has the highest accuracy value of 0.9982. The SVM method is known to have computerized time, Area Under Receiver (AUC) and the best accuracy among the other three methods [9].

Research conducted by A. Nguy-Robertson et al discusses the estimation of chlorophyll elements in corn plants carried out with two approaches, namely calculating Leaf Area Index (LAI) and leaf color using Leaf Color Chart (LCC) as shown in Fig. 1. From the verification results the estimated value obtained from the two approaches has not succeeded in displaying the right results even though the error value is still relatively reasonable. The use of LCC in estimating chlorophyll from a plant becomes a cheap solution without having to develop new technology [10].

III. Research Metodology

This research implementation has been carried out in the form of experiments on research object which is corn leaves images. The MATLAB application in this study was used to process corn leaves image that had been processed through pre-processing stage. To achieve its objectives, this research was carried out based on research methodology as shown in Fig. 2.

First step of this research is to collect corn leaves images which is done by taking images directly from corn field. The image was taken in Padang Raya Village, Halong District, Balangan Regency, South Kalimantan using a smartphone camera. There are 5 types of corn leave that have been taken including normal leaves, nitrogen deficiency leaves, potassium deficiency leaves, phosphorus deficiency leaves, and dry leaves as show in Fig. 3. Division of testing and training data amount in a ratio of 30:70 respectively using train/test split method in one of the Python programming language packages. Each type of leaves will be grouped and labeled with number 1-5 before being processed at next stage.

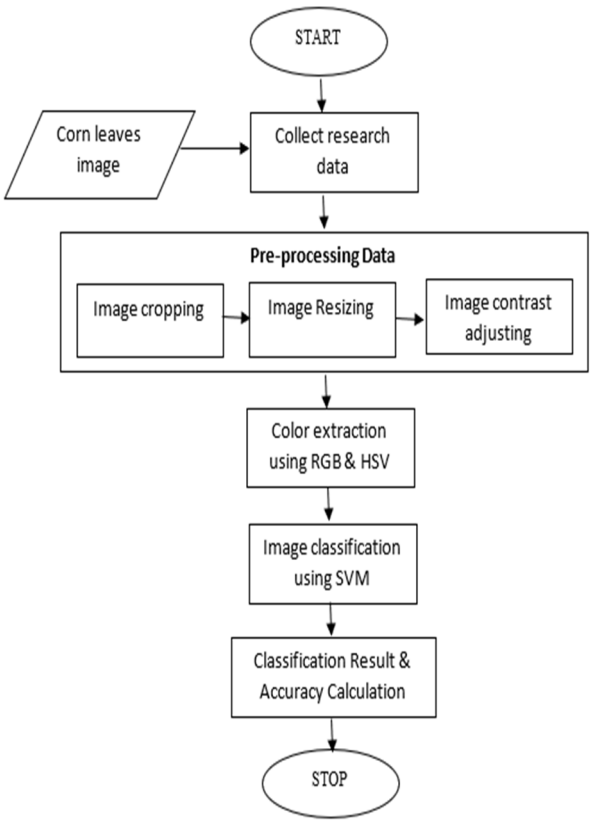

Fig. 2. Overview of Research Methodology

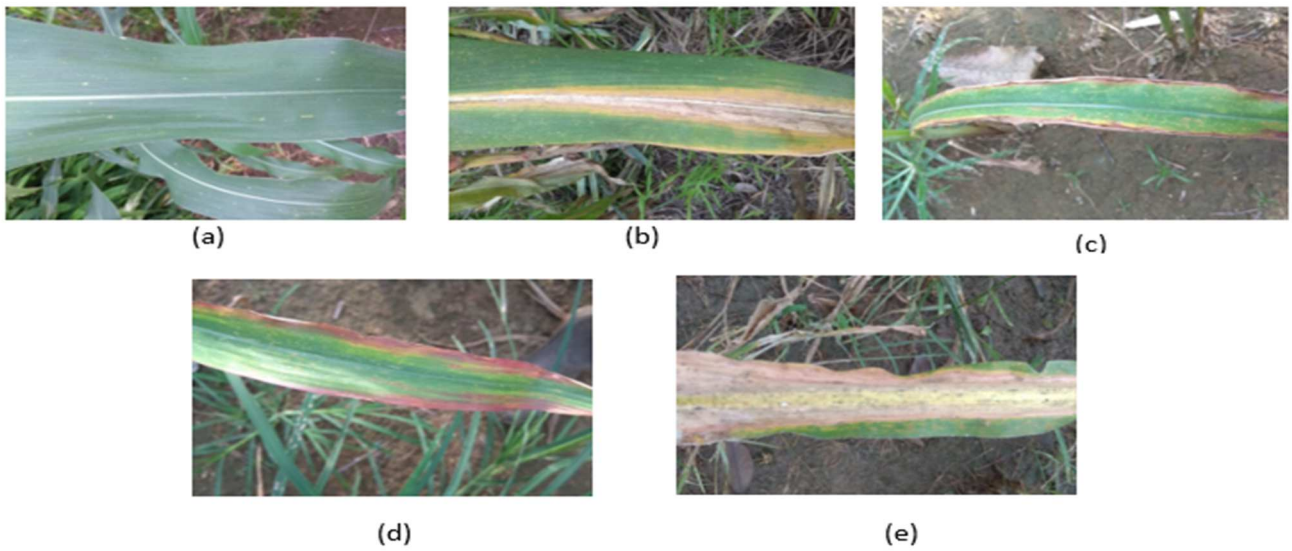

Fig. 3. (a) Normal Leaves, (b) Nitrogen-deficient Leaves, (c) Potassium-deficient Leaves, (d) Phosphorus-deficient Leaves, (e) Dry Leaves

Nitrogen-deficient leaves have yellow to dry at center of its base as shown in Fig. 3(b). Corn leaves that have yellow to dry on its leaf edge in Fig. 3(c) are examine as potassium deficient leaf. Other leaves image as shown in Fig. 3(d) diagnose as phosphorus-deficient leaves have a slight of purple color on it. At last image of Fig. 3(e) it shows dry leaves that has nutrition deficiency.

Next step of research methodology is data pre-processing which must be done to preparing image data prior to RGB and HSV color extraction. The initial process of image pre-processing is to remove noise from collected corn leaves images by removing parts that are not needed for the next process. Process is done by cropping corn leaves image to remove image background so the color value of corn leaves can be detected. Following this process, adjusting color contrast and removing noise are done to corn leaves image before resizing into 30x70 pixels as shown in Fig.4.

After going through pre-processing, it is continued by digital image processing, namely by color extraction process by using RGB and HSV sequentially. First extraction process is generated RGB value of color leaves image. This process is carried out by using MATLAB application to calculate the

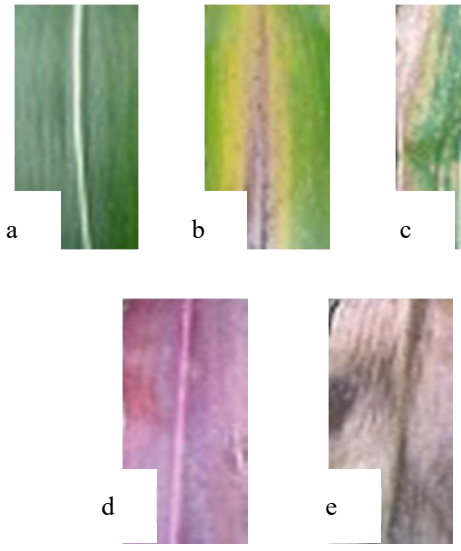

Fig. 4. Corn Leaves Image After Cropping

average value of the RGB of each image pixels. This average value will be used as representation of its image RGB values that calculated based on formula (1) as below[11], [12].

$$R = \frac{R}{255}; G = \frac{G}{255}; B = \frac{B}{255} \quad (1)$$

Second step of color extraction process after getting its RGB value is convert it into Hue Saturation Value (HSV) using formula (2) as shown below[13], [14].

$$V = max$$

$$S = \begin{cases} 0, if\ \Delta = 0 \\ \frac{\Delta}{max}, if\ \Delta <> 0 \end{cases}$$

$$H = \begin{cases} 60\frac{G-B}{\Delta}, if\ \mathrm{R} = max \\ 120 + 60\frac{B-R}{\Delta}, if\ \mathrm{G} = max \\ 240 + 60\frac{R-G}{\Delta}, if\ \mathrm{B} = max \end{cases}$$

$$H = H + 360, if\ H < 0 \quad (2)$$

After getting HSV value, it is converted into range of [0,255]. before calculate its average value of the HSV pixels. Average value of HSV, will be used in classification process using Support Vector Machine (SVM) method. Example result of corn leaves images color extraction into RGB and HSV as shown in Table 1.

TABLE I. RGB HSV COLOR EXTRACTION RESULT

R	G	B	H	S	V	Label
125.638	164.648	148.981	156	23.7	64.6	1
108.031	149.263	100.521	111	32.7	58.5	1
109	143.237	110.59	123	23.9	56.2	1
99.9314	143.057	90.9306	110	36.4	56.1	1
106.457	148.853	114.588	132	28.5	58.4	1
164.708	175.918	102.643	69	41.7	69	2
174.332	182.164	109.047	66	40.1	71.4	2
174.739	173.631	98.3863	59	43.7	68.5	2
196.079	190.844	145.345	54	25.9	76.9	2

R	G	B	H	S	V	Label
192.547	188.354	127.375	56	33.8	75.5	2
107.132	133.101	98.3025	105	26.1	52.2	3
185.489	197.806	125.995	70	36.3	77.6	3
169.11	184.49	110.955	73	39.9	72.3	3
164.941	181.052	97.1083	72	46.4	71	3
152.1	162.021	115.981	73	28.4	63.5	3
117.75	107.571	109.141	351	8.1	46.2	4
116.9	104.62	115.266	308	10.5	45.8	4
163.932	152.749	164.088	299	6.9	64.3	4
187.299	138.161	175.505	314	26.2	73.5	4
180.305	159.166	169.566	330	11.7	70.7	4
73.276	160.249	157.119	12	9.3	68	5
176.554	172.284	166.612	34	5.6	69.2	5
150.23	143.015	140.578	15	6.4	58.9	5
169.012	151.899	149.331	8	11.6	66.3	5
171.385	167.197	145.324	50	15.2	67.2	5

All of 117 images data that has been through pre-processing and color extraction using RGB and HSV will be categorized into 5 category of corn leaves. They are divided into 92 training data consist of 20 images for normal leaf, 19 images of nitrogen deficiency leaf, 18 images of potassium deficiency leaf, 15 images of phosphorus deficient leaf and 20 images of drought leaf data. As for testing data are consist of 5 images for each category with total of 25 data testing for this study.

After color feature extraction step has been done, last step of this research methodoloogy is corn leave images classification using *Support Vector Machine* (SVM). SVM is one of classification method that part of supervised machine learning algorithms which relies on statistical learning [15]–[17]. Appropiate parameters are expected to increase SVM accuracy so choosing optimal parameters is one of success key when using SVM as classification method [18]–[20].

After classification process is done, classification result of corn leaf images using SVM will be evaluated using classification report. Value that will be examine are precision, recall, F1-score and accuracy. Fig. 5 shows classification stages of corn leave images using SVM.

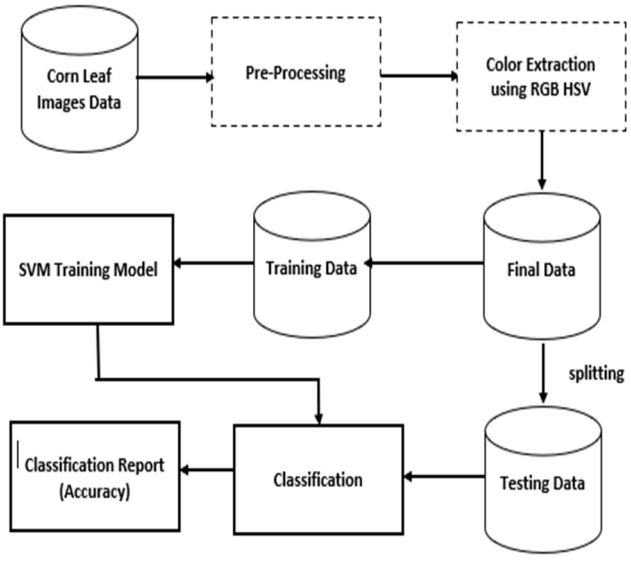

Fig. 5 Corn Leaf Images Classification Stages

IV. Result And Discussion

Main purpose of this study is to detect corn leaf images nutrition deficiency based on classification result using digital image processing and SVM. First step of classification stage is to split processing corn leaf images for training and testing. Training data of corn leaf images are tested using SVM with range of parameter values C=1.0-3.0 and σ=0.1-1.0. Training process are use these parameter values to get better combination based on highest accuracy.

After got best combination value, a system is created using SVM algorithm using its value. This system is create using Phyton programming language to implement the best SVM algorithm that have been trained. Purpose of this system is to test corn leaf images testing data using its SVM algorithm for detecting nutrition deficiency based on its leaf color.

Performance of classification system can be measure using classification report. A classification report is used to measure the quality of predictions from a classification algorithm. This method is used to check how many predictions are true and how many are false. More specifically, true positives, false positives, true negatives and false negatives are used to predict the metrics of a classification report.

For this research, classification report will examine its precision, recall, F1-score and accuracy value. Examination on this research compared between classification result from system that used SVM algorithm and manual data. Table 2 below will be show result of classification report of SVM algorithm that used in classification system that detect nutrition deficiency of corn leaf images.

TABLE II. CLASSIFICATION REPORT

Label	Precision	Recall	F1-score
1	67%	100%	80%
2	100%	50%	67%
3	50%	50%	50%
4	100%	100%	100%
5	100%	100%	100%
Accuracy			80%
Macro avg	83%	80%	79%
Weighted avg	83%	80%	79%

From classification report above, it shows that most of value such as precision, recall and F1-score are above 50%. As classification result for phosphorus deficiency and dry leaves it reached 100% for all result. Based on result above, it also shows that accuracy rate of SVM algorithm that used by classification system in this research is 80%.

V. Conclusion

Based on testing process of this research, it shows that Support Vector Machine (SVM) model used has been successfully made to detect nutrient deficiency of corn plant based on its leaf images. Classification report shows that SVM model that used in this research has reached 80%

accuracy value with mostly precision, recall and F1-score were above 50%. From this result, it shows that to reach more accurate model, we need to combine optimal parameters to get better result. Quantity of data used for training process may also affect the accuracy value of SVM model so it can learn more variations of corn leaf images. For further research, it should be done to select features from other variable that can be used to detect nutrient deficiency except than its leaf. Classification method for next research can used other method to predict nutrient deficiency of agriculture plant for better result.

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